Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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Remarks made by W. L. SAUNDERS in discussing the paper entitled:

"Electrical Apparatus for Coal Mining,"

by W. B. CLARKE, Schenectady, N. Y.,

at the Albany Meeting of the American Institute of Mining Engineers, February, 1903.

Notwithstanding the sweeping statements made by Mr. Clarke in this paper the friends of compressed air are not dismayed. There is no war between electricity and compressed air. Each one has its field of usefulness and in that field each is supreme. In spite of commercial interests, in spite of prejudices and the enthusiasm of the inventor, the thing that is best will survive and flourish.

At least ten years ago, our engineering papers contained large advertisements and pages of reading matter about the application of electricity to mines, recording the introduction of numerous rock-drilling plants, and claiming that the problem had been solved greatly to the advantage of the miner and with promise of large profits to the manufacturers of electrical apparatus. Edison and Thomson labored to apply electricity to mines and each believed that the probabilities of success were great. This was the period of the solenoid rock drill, which was admirably suited, theoretically, to the percussive principle and in the development of which hundreds of thousands of dollars have been spent without satisfactory result. I have searched in vain for a standard mining equipment where electric rock drills are in constant, commercial operation. During a recent trip made from New York to California I visited most of the important mines of the West and failed to discover a single electric equipment, so far as this class of mining work is concerned. If any one will inform me where there exists to-day an electric drilling equipment in constant service in mines in the United States, I shall be glad to receive the information.

Mr. Clarke has been for some years an active and intelligent writer on the subject of electricity for mining. Whenever his papers have appeared we have read them with interest; for in many cases his arguments in regard to the operation of electric motors have been used effectively as arguments in favor of compressed air, especially in connection with mechanical haulage. Mr. Clarke mentions the adaptability of electric apparatus to coal-mines and the high efficiency of the electric system. There is no place where the pneumatic engineer has an easier time when competing for the introduction of machinery than in a coal mine. Air is exactly what is wanted in such a mine and electricity is what is not wanted. The one is safe and healthful, the other dangerous and destructive. The following extracts are taken from the Report of the Pennsylvania Department of Internal Affairs for 1899, Part V of the Report of Bureau of Mines:

"Besides the increase in danger from ex-"plosive gases, other elements of danger "have been introduced into the mines by "the use of mining machines and elec-"tricity. These have been introduced dur-"ing the past ten years, and it is the "opinion of the writer that the use of "electricity in any form in coal mines is a "menace to life, limb and property."

This report, for 1901, says:

"Electricity is one cause of fatalities in "the bituminous mines (seven having lost "their lives through it during 1901), that "so far has not proved fatal to any per-"son in the anthracite mines. Electricity "in various forms has been the cause of "many deaths in the soft coal mines, either "from the men coming in contact with the "electric trolley wire, or with the electric "wire that carries the power to the elec-"tric cutting machines. In my opinion, "separate traveling ways should be pro-"vided for the workmen when the haulage "is done by electricity, unless the wires can "be raised to a distance of at least six "feet from the rail, and even then there "should be sufficient room for passing on "the main haulage roads at all points as "men cannot always reach the 'safety "holes' in time. In every case where elec-"tric machines are used for cutting coal, "the wires should be made absolutely safe, "as men in the hurry of their work forget "about the 'deadly wire,' touch it, and all "is over, and the report follows 'killed by "an electric shock.' Humanity demands "protection for the workingmen from this "most deadly agent recently introduced "and employed in coal mines. I hope the "time will come when 'compressed air,' " 'liquid air,' or some other agent will sup-"plant electricity in coal mines.

"In gaseous mines, electric cutting "machines or other electric motors should "never be permitted in use, as otherwise "sooner or later they will be the cause of "a great catastrophe."

It cannot but be of interest to the members of this Institute to read the following statement of "The Difficulties Which Must Necessarily be Met, and Some Means of Reducing the Dangers of Faulty Insulation," which has formed the subject of an admirable paper by Mr. Alton D. Adams in the November, 1900, issue of *Mines and Minerals:*

"In but few other places are so many "conflicting requirements to be met, as to "electric wiring, as in mines. Distances "over which the electric energy must be "distributed are often so great that com-"paratively high voltages are necessary to "economy in the copper conductors. The "higher the voltage of circuits, the greater "the necessity for a high degree of in-"sulation, and yet the conditions in mines "are such that most wires must be run "bare. If wires of comparatively high "voltage must be used without an insulat-"ing covering, it is desirable that they be "erected beyond the easy reach of men and "horses, but the head room in mines is "often such that this precaution cannot be "taken. The large amount of moisture "present in a mine renders it very diffi-"cult to maintain any high degree of in-"sulation on wires unless they have a "covering of rubber, and the sulphur pres-"ent in the moisture of many mines, espe-"cially those of coal, rapidly ruins rubber "insulation. The result is that circuits of "comparatively low pressure are frequently "run with bare wire. A moderate amount "of insulation from the earth is obtained at "the points of support, by using only large "porcelain or glass insulators for the at-"tachment of the wire. Care should be "taken to have the wires touch nothing "save their insulating supports, and porce-"lain tubes are convenient in some cases "for this purpose, where the sides or ceil-"ings of passages are uneven. Such tubes "should also be used in every case where "wires go through partitions. With bare "copper circuits, in mines where there is "much moisture, the most careful work "will not ensure a high resistance to earth, "because of the films of moisture that col-"lect on the surfaces of the porcelain and "glass. While this moisture on insulators "is not usually sufficient in amount to "cause any serious loss of power, it may "well cause a severe shock to one who "makes a single contact with the circuit, if "his body is also in electrical connection "with the ground. The existence of these "conditions points to the conclusion that "all distribution circuits in mines should "be operated at a voltage that is not ordi-"narily dangerous to the life of man or "beast, so far as possible.

"Three kinds of electric service must "usually be provided for in mines, light-"ing, stationary motive power, and hauling.

"The voltages of circuits for these pur-"poses are apt to vary somewhat accord-"ing to the kind of electrical supply "adopted. The only satisfactory motors "available for traction purposes are those "of the direct current type. Such motors "may be operated at any voltage within "wide limits, but the prevailing pressures "for railways in mines are 250 and 500 "volts. Stationary motors of the direct "current type are usually operated at 220 "or 500 volts to correspond with generators "for incandescent lighting or with the trac-"tion system. Satisfactory induction mo-"tors operated by two or three phase alter-"nating currents, are now in use. These "motors are usually supplied by trans-"formers distant not more than a few "hundred feet, and there is therefore, no "reason for a voltage higher than 250 on "their local circuits. If incandescent lamps "are supplied with direct current, the vol-"tage on the two wire system must be "about 125 or 250 to correspond with those "of lamps. In case the three wire system "of distribution is employed for the cir-"cuits, their maximum pressures will be "twice those just named, or 250 and 500 "volts, according to the pressure required "at lamps. Lamps on alternating current "circuits are usually supplied by compara-"tively near transformers, and there is "slight incentive to use maximum pres-"sures greater than 125 volts on the two "wire or 250 volts on the three-wire sys-"tem.

"With these facts, as to the general re-"quirements and limits for electric pres-"sures in mine work, in mind, expedients "for greater safety and convenience of "operation may be considered. The stand-"ard pressure for electric street railway "lines all over the country is 500 to 600 "volts. The Edison three-wire system of "distribution, as extensively used by cen-"tral stations has very generally employed "a pressure of about 250 volts between its "outside wires. Experience, gained from "these two extensive classes of circuits, has "demonstrated that 500 volts is sufficient "pressure to readily kill a horse and even "a man, when a good contact with both "sides of a circuit is made. On the other "hand it has been equally well demon-"strated that 250 volts will not kill a man "under any conditions as to contact that "are at all likely to exist in practice, but "this conclusion does not follow as to a "horse. In mines, where both men and "mules are liable to make contacts with "live circuits of bare wire, it seems highly "desirable that their voltages be limited if "possible to 250, and especially that the "difference of pressure between either "side of any circuit and the ground be not "greater than this amount. As above "pointed out, there is seldom any good "reason for a pressure of more than 250 "volts on the alternating current circuits "for incandescent lamps and motors in "mines. Direct current distribution to "both incandescent lamps and stationary "motors may be carried on in mines at "maximum pressures of either 250 or 500 "volts, with corresponding possible differ-"ences of pressure between any wire and "the earth of 125 or 250 volts respectively. "This result is reached by the expedient, "very generally adopted in Edison city "systems, of grounding the third or so "called neutral wire of the three-wire sys-"tem. Accidental contact is seldom made "with more than one electric wire at the "same time, and a shock, from one side of "a three-wire system with a grounded neu-"tral, is given with only one-half of the "maximum voltage. The conditions as to "the insulation of circuits in mines, as "pointed out, are such that the maker of "contact with one side of an electric cir-"cuit is quite apt to receive the maximum "pressure of the circuit unless it has a "grounded neutral. The moderate pres-"sures necessary on transformer circuits "and the grounded neutral of three-wire "systems thus greatly reduce the dangers "from circuits for lighting and stationary "motors in mines.

"Most dangerous among electric systems "in mines are the trolley or railway cir-"cuits. The wires leading to lamps and "stationary motors may be grounded, so "that a person touching either wire will re-"ceive the maximum pressure, though this "is not usually as much as 500 volts. "There is, however, some chance of "escape without injury from accidental "contact, since the ground connections on "the lamp or stationary motor circuit may "be slight, or the electric pressure of the "circuit may be low. One side of the "street railway system of electric conduc-"tors is, however, permanently and se-"curely grounded by the use of the track "as all or a part of the return circuit. Any "one touching the trolley or the uninsu-

"lated feed wires is therefore subject to the "full difference of pressure between the "two sides of the system, if they are in "electrical connection with the ground or "rails. In places where the pressure on "the electric traction system in mines is "kept at about 220 volts the probable dam- "age to men or animals is very slight, but "repeated and serious injuries have oc- "curred in mines where 500 volts are em- "ployed. The very material incentive to "the use of the 500-volt traction system is "the fact that, compared with a system "having 220 volts as a maximum, it saves "75 per cent. of the necessary copper in "conductors, all other factors remaining "constant. This consideration is of espe- "cial weight in those instances where dis- "tances are so great that the relative "amount of the investment for copper is in "any case large. Fortunately, however, "there is a means, though it has not been "generally employed for the purpose, by "which the advantages of the 500-volt "traction system in mines can be retained "and at the same time the pressure be- "tween the trolley or any of its feeders "and the earth or rails limited to 250 volts. "This result is reached by applying the "three-wire system, long successfully used "for lamp and stationary motor circuits, to "traction circuits in mines. For this pur- "pose two trolley wires should be used, "one connected to each side of the trac- "tion generator, or to the free sides of two "generators in series. If only one gener- "ator is used, the conductors from the "rails to the power station should be con- "nected to a small dynamotor, designed to "keep the rail pressure halfway between "that of the main terminals. If two "generators are used in series for the trac- "tion lines, then the rail conductors should "be taken to their common connection. "On a double track road, one trolley wire, "representing one side of the system, "should be erected over the center of each "track, but for a single track road one "trolley may be located about over each "rail. In this latter case trolley poles "should be mounted near one side instead "of on the center of cars or locomotives "and about one-half of them take current "from each trolley. This arrangement "evidently makes the rails the third or "neutral wire of a three-wire system, and "any accidental contact between either "trolley wire and the rail or ground is ex- "posed to a pressure of 250 volts, when the "voltage between the two trolley wires is "500. Contact through accident with both "trolley wires at the same instant is im- "probable, and the three-wire thus offers a "decided increase of safety over the two- "wire system with 500 volts between trol- "ley and rails. While the low pressure "circuits for lamps and stationary motors "are quite safe as to their own voltages, "there is danger from another source in "those cases where these circuits run from "alternating current transformers that are "supplied by high pressure lines. This "danger arises from the fact that a ground "connection at any point on the high "pressure circuit and a cross between the "high and low pressure circuits inside the "transformer or elsewhere, exposes one "who makes contact from the low pressure "to the earth at any point to the voltage of "the high pressure circuit. Such an acci- "dent would probably result fatally, as the "primary alternating lines usually oper- "ate at pressures as great as 2,000 or "3,000 volts. This danger can be very "largely averted by a substantial and per- "manent connection between one wire of "every secondary circuit and the ground.

"If the secondary circuits from trans- "former are on the two-wire plan, either "side may be connected to earth, but if "they are run three-wire the neutral should "be so connected. The connection to "ground when properly made is of much "lower electrical resistance than the body "of a man or animal and the only damage "likely to result from a cross between the "primary and secondary circuits is a blow- "ing of fuses. The high pressure primary "lines to transformers should be kept out "of the parts of mines in which work is "going on, as far as possible. Rubber "covered wires, cotton braided and with a "sheath of lead on the outside seem to be "the best material for the primary cir- "cuits. Where high pressure wires are "exposed to mechanical injury, as in ver- "tical shafts, the rubber and lead covering "just mentioned should be used and a "substantial iron pipe erected, into which "the leaded wire is subsequently drawn. "It is not necessary to have any lining of "insulation for the iron pipes, or to supply "insulating supports for it."

These are but a few of the many state- ments made from time to time by men of

practical experience in coal mines. Electricity, with all its usefulness and value to mankind, is not the best power to be taken down into a mine where gases and dust are liable to accumulate and where human life is endangered by the electric spark. In cases of this kind the question of efficiency is of little or no importance when compared with greater and more serious questions, and in face of the facts with which the members of this Institute are familiar, I deny Mr. Clarke's statement that the coal mine is "a field to which the electric motor seems to be especially adapted."

As to the pneumatic mine-locomotive, the statement is made that it "is not an unqualified success," and among the reasons stated are that "its radius of operation is restricted." A mine-locomotive which is absolutely restricted to the limits of a trolley-wire would seem to have a more limited radius than one which is independent of any wire or connection, which carries its own power stored in tanks and which might go anywhere and on any track to the extent of its storage-capacity. Such is the pneumatic locomotive, the first of which for mining purposes was built in the late eighties and early nineties, and of which probably not more than six or seven were in use in 1895, while to-day there are at least 150 of these locomotives in successful operation in mines, 125 of them having been built during the last three years. This record will, I think, compare favorably with that which can be shown by the manufacturers of electric mine-locomotives. For a more detailed study of this subject I beg to refer to a very practical paper by Mr. J. H. Bowden, Chief Engineer of the Susquehanna Coal Company, entitled "Compressed Air Haulage Plant," at No. 6 Colliery of the Susquehanna Coal Co., published in the transactions of the American Institute of Mining Engineers in the year 1900. In this paper Mr. Bowden shows that by the use of air-haulage as against mule-haulage the total saving in two years was almost equal to the total cost of the air-haulage plant; and he goes on to say that "at the average rate of saving for 1897 and 1898, the entire cost of the plant would be saved in 361 working days." I am indebted to Mr. E. P. Lord, General Manager and Superintendent of the H. K. Porter Company, of Pittsburg, for the following comparison of cost of haulage in coal mines by means of compressed air and electricity:

"Figures for compressed air haulage "taken from a paper read by J. H. Bowden, Chief Engineer of the Susquehanna "Coal Co.

"Figures for electricity taken from the "catalog of the General Electric Co., No. "1030, entitled 'Electric Mine Locomotives,' published August 6, 1901.

"The compressed air haulage plant is "located at Glen Lyon, Pa., No. 6 Shaft "and No. 6 Slope of the Susquehanna "Coal Co.

"The electric haulage plant is located at "Forest City, Pa., No. 2 Shaft of the Hill-"side Coal & Iron Co.; Mr. W. A. May, "Superintendent.

"The compressed air haulage plant was "installed 1895 and 1896: One locomotive, "one compressor and the pipe line for the "shaft locomotive, September, 1895; the "slope locomotive and the pipe in May, "1896. A second compressor was ordered "April 7, 1900, to provide sufficient air for "the increasing length of haul and output. "The figures given are for the year 1898.

"For the electric haulage plant I do not "know the date it was installed or the "year for which the published figures are "given.

"Both plants used two locomotives.

"Column 1 is taken from Mr. Bowden's "paper, with the exception of the cost per "ton, which was calculated by the writer. "Mr. Bowden reduces the cost to the ton-"mile unit. The cost per ton-mile given by "Mr. Bowden is 1-93/100 cents. The aver-"age length of haul was less than one mile, "hence the cost per ton hauled is less than "the cost per ton-mile. The other costs "per ton were taken direct from the cata-"log of the General Electric Co.

Items.	1 Cost of Compressed Air.	2 Cost of Electricity.	3	Remarks.
"Number of working days "per year	160	200+	141¼ =	(+) Estimated for (=) Actual time.
"Output per day, tons	2362½	989	989	Mr. Bowden in his paper figures 1245 ton-miles per day. Figure in Column 1 is tons of coal hauled.
"Engineer, power house	$1.16	$1.20	$2.84	
"Motorman	4.20	4.23	9.31	
"Helpers (brakemen)	3.20	3.20	3.61	
"Electrician	——	1.67	3.68	
"Repairs to motors	.74	5.95	8.42	
"Repairs to line	——	——	.46	
"Repairs to generator	.57		.61	
"Fireman			2.50	
"Depreciation at 5%	4.74	5.20	8.17	
"Interest	4.73		4.41	Compressed air, 5%. Electricity, 3%.
"Interest, repairs and depreciation, 174 H. P. "boiler	1.63	——	——	
"Oil and waste for motor.	.25	.22	.35	
"Do. for generator	.47		.74	
"Steam (fuel and firing)	2.32			
"Totals	$24.01	$21.67	$45.10	
"Cost per ton	.01015	.02192	.0456	

"Conditions unknown to the writer "might have a tendency to compensate "partially for the great difference in cost; "but it would be hard to find conditions "sufficiently unfavorable to the electrical "haulage to entirely equalize them.

"The ton-mile basis is not a fair basis "of comparison, as the delay at terminals "forms so large a part of the entire time "consumed by the locomotives. The time "lost in this way would remain a fixed "quantity regardless of the length of haul, "and therefore if the haul were longer the "locomotives would make a better show-"ing on the ton-mile basis.

"The compressed air locomotives under "consideration were respectively the fourth "and fifth ever built by the H. K. Porter "Company, and were crude in many ways "when compared with the compressed air "locomotives now being built. We have "no doubt that the electric locomotives "built for the Hillside Coal & Iron Com-"pany were also inferior in many ways "when compared with the present product "of the General Electric Co. But why "should one type improve more than the "other?"

As to efficiency, it is not denied that the efficiency of an air locomotive, like the efficiency of all locomotives, is low. Probably 20 to 30 per cent. is correct when applied to air-locomotives which do not reheat the air before use. It must be denied, however, that the efficiency of an electric locomotive is 55 per cent. In figuring on haulage-plants for mines we have been told by reputable men that the estimates of boiler-capacity for the pneumatic plant were substantially the same as those furnished by bidders of electrical apparatus. In a paper written by Mr. Clarke for "Mines and Minerals," in July, 1901, en-

titled "Electricity *vs.* Compressed Air—A Comparison of the Efficiencies and Relative Cost of Installation of the Two Systems," he makes the statement that 150 H. P. of boilers will be required to operate his supposed electrical installation and that in the case of compressed air the steam engine driving the compressor was actually indicating 150 H. P. Mr. Bowden makes the statement, in connection with the paper which Mr. Clarke is criticising, that he estimates the steam consumption at 174 H. P., and further, that a second compressor is being installed, from which Mr. Clarke infers that the final steam consumption will be 300 H. P. This cannot be the case, as the present compressor is doing the work, and the installation of the second compressor will simply allow the original machine to be operated at below its normal capacity without any increase in the steam consumption. But in no case would one be led to believe that there was a difference in efficiency of 20 per cent. for compressed air and 55 per cent. for electricity.

As to the relative cost of an air and an electric plant, Mr. Clarke makes the statement that a compressed-air plant "costs from two to three times as much as an equivalent electric mine-haulage system." With all due respect for Mr. Clarke, I must maintain that this statement is incorrect. The relative cost of any two systems would vary with conditions. The facts are that in putting in bids for pneumatic installations we have found that at times the difference in cost has been from 50 per cent. in favor of compressed air to 50 per cent. against compressed air, according to the conditions; and we may say in a general way that the cost of an electric installation is lowest when operating on a single entry, involving the minimum amount of wiring, whereas, when a number of diverging roads occur, the independent nature of the compressed-air locomotive, which allows it to operate over lines without any previous preparation or expense places it in the most advantageous position.

In the early part of Mr. Clarke's paper he alludes to "weaknesses" which have developed in the use of electricity in mines, and goes on to say that this matter has received attention, and improvements have been made which have facilitated "the repairs and renewals." Later on in his paper, when comparing the pneumatic with the electric locomotives, he speaks of the former as "relatively complicated" and "subject to very frequent repairs." This is rather rough on my friends in the air line, especially so as it is a fact that an air locomotive is a simple machine differing little from the well known perfected mechanism of the common locomotive, and that it is very much more simple in its construction and very much less liable to repairs than an electric locomotive. We have no better authority on this point than Mr. Clarke himself, who in his paper in "Mines and Minerals" of July, 1901, previously cited, says:

"The operating expenses of the electric "haulage system would not be much less "than those of the compressed air sys- "tem."

It may be added that the H. K. Porter Company, in a number of cases, although local conditions have made the initial cost relatively high, have received orders solely because an unprejudiced investigation made by disinterested parties has shown that the operating expenses of the air plant, particularly in the question of repairs, have been so much less than those of the electric haulage system that the difference would pay a handsome return upon the initial investment. Furthermore, I desire to call attention to a discussion in *Mines and Minerals* of Mr. Clarke's paper of July, 1901, in which the following correspondence occurs:

"(In order that the above discussion "may be fully understood, and since Mr. "Bowden, who prepared the paper which "is used as the basis of Mr. Clarke's fig- "ures, has died since his paper was printed, "we have submitted Mr. Clarke's figures "to Mr. Bowden's successor as chief en- "gineer of the coal companies of the Penn- "sylvania Railroad Co., Mr. R. Van A. "Norris, whose answer is appended.)"

"Mr. H. H. Stoek, Editor *Mines and Min- "erals,* Scranton, Pa.:

"Dear Sir:—I return to you herewith "the article 'Mine Locomotives, Electricity "*vs.* Compressed Air,' by Mr. W. B. "Clarke. I have made calculations simi- "lar to those made by Mr. Clarke, and "believe his conclusions to be practi- "cally correct as far as they go. But "there are other conditions besides econ- "omy which have decided us in favor of "compressed air haulage; the principal "ones being the gaseous character of the "mines, in which the possible sparking of "an electric machine would be a source of "grave danger; the simple character of the "mechanism of a compressed-air locomo- "tive, which is within the capabilities of a "colliery plant to keep in order and re- "pair; the advantage of having consider- "able radius of action beyond the charging "stations, and the beneficial effect of the "air on the ventilation of the mine.

"As was shown in Mr. Bowden's paper, "the cost of power is but a small fraction "of the total cost of operation, the saving "for even a 50 per cent. decrease in the "steam used being but .09 of a cent. per "gross-ton mile.

"As an evidence of our entire satisfac- "tion with this method of haulage, I "might add that we have just ordered an- "other compressed-air haulage plant com- "plete for our No. 1 shaft, Nanticoke, Pa.

"Yours very truly,
"R. V. Norris,
"Chief Engineer."

The foregoing statement made by Mr. Norris refutes the argument that the pneumatic locomotive is complicated. Mr. Norris' experience and knowledge of this subject are beyond dispute. In connection with the matter of repairs it may be well again to quote Mr. Clarke, who wrote as follows in *Mines and Minerals* in April, 1901:

"'Electric Mine Locomotives—Things "to be Observed in Choosing, Operating "and Caring for Mine Locomotives to "Secure Greatest Economy."

"Annoying delays are often experienced "at mine-haulage plants, where there are "several locomotives, due to the frequent "'blowing' of the circuit breakers. It is "proper, of course, that the circuits should "be automatically opened, when the gen- "erator is called upon to deliver a current "beyond its safe capacity, but it is annoy- "ing if the service is interrupted with too "great frequency. The remedy for this "trouble also lies, to a very great extent, "in the hands of the motorman, as the "intelligent use of the controller will "minimize the demand upon the generator. "This trouble is aggravated by the simul- "taneous starting of all of the locomotives "when the circuit breaker is reset by the "engineer at the power house, since each "locomotive requires a comparatively large "current when starting, and the sum of "their starting currents is often sufficient "to immediately blow the circuit breaker "again. In this way it often happens that "the circuit breaker is thrown out several "times in rapid succession, and the entire "haulage system may be interrupted for a "half hour or more. The engineer occa- "sionally becomes righteously indignant, "allows the circuit breaker to remain out "a few moments before resetting it; and "the relations between the employes of the "power house and the motormen become "strained, with no good results to the "company."

In this paper also Mr. Clarke advocates, where a number of electrical locomotives are employed, the establishment of an inspecting force, which shall work all night in cleaning and hunting for defects and making repairs; and further, that a spare armature or two should always be carried in stock, together with other repairs, and that this is necessary in order to avoid the delay and expense due to the loss of the use of the locomotive, the consequent reduction of the output, the express and telegram charges, not to mention the annoyance that can be avoided if the locomotive is regularly inspected, and if extra parts are carried in stock at the mine.

His summary at the end of this article (the seventh clause) reads:

"Last and most important, establish a "rigid system of inspection and carry *a "liberal stock of repair-parts."*

We might add to this a little advice to anyone who contemplates an electric installation, that he be prepared to take care of all repairs promptly, that he employ an experienced electrician and that he have a shop sufficiently equipped to provide for such repairs as will be inevitable. It is a well known fact that in the mines of the Pittsburgh Coal Company there are several shops located at central points in which they constantly employ a number of skilled mechanics for making repairs to electrical equipment used in their mines, and that in the large syndicate of mines controlled by the Pittsburgh Coal Co., comprising 70 or 80 different mines, only two are equipped with air haulage plants; one of the air haulage plants having been installed thirteen years, yet it is stated by experts familiar with the operation of these mines, that in the matter of cost of repairs and safe, uniform service, these air plants have given less trouble and have cost less than any of the electric plants at other mines. There are, of course, places where electricity is particularly well adapted for mine-haulage and where it is to be preferred possibly to any other means, but those places do not exist everywhere, and it is unfair to state the broad principle, that electricity is better suited for mine-haulage than compressed air.

It is a common thing to hear from electrical sources that compressed air gives a low efficiency. A restricted definition of the word efficiency is, the proportion of the power generated by the coal consumed under the boiler which is delivered by the machine in question. But in the broad, practical sense, namely, that of capacity to accomplish work in the best manner consistent with all conditions, the advocates of compressed air claim that, as compared with all other powers, it is supreme in mines. It is common to criticise the efficiency of a percussive rock-drill. The catalogs of electric-drill manufacturers have invariably stated comparisons showing that an electric-drill consumes from two to three H. P. as compared with 8 to 10 H. P. in an air-drill. But in the first place, the figures of electrical power consumption are largely theoretical, while those of the air-drill are based on an experience of forty years. There is no doubt about the fact that an air-drill when doing good service in a mine will consume from 8 to 10 H. P., but in doing this it does its work; it gets the hole in; it makes progress; it costs the minimum amount in repairs when compared with the number of linear feet of hole drilled. In these respects the air-drill is the most efficient machine at work in a mine to-day. Think for a moment of the hard work done by this "pounder." Here is a machine light enough for two men to handle and yet containing within itself the capacity to make a hole in a piece of hard granite or trap rock at the rate of from 2 to 5 inches a minute. The machine consists of little more than a piston, a valve and a cylinder, as these are the principal moving parts. The power is led through a piece of hose which in itself is certainly a simple piece of mechanism, and the compressed air is conducted alternately to one end of the cylinder and the other, thus causing the piston to strike its blows. Unless some one discovers a better way to drill rock than by the hammer-blow it is likely that the air-drill will stand supreme for a great many years to come. No electric drill that has thus far been devised has equalled it in simplicity; and it is certain that no electric drill has ever equalled it in drilling-capacity, which is really the measure of efficiency.

The little air-compressor which is mounted on the hip of a locomotive is another example of efficiency in air-apparatus. This Westinghouse pump has been pointed to as a wasteful machine, and if it were used to drive the shafting of a shop it would be wasteful; but when applied to the air-brake, taking its power from the boiler of the locomotive, storing it in tanks along the train and using it at the proper time to throttle the wheels and bring to a standstill within a few hundred feet a train weighing many tons, and moving at the rate of a mile a minute, it is the most efficient device known to mankind. There is another little air-device used to move switches, known as the electro-pneumatic system of switching. This is an admirable illustration of efficiency and it also illustrates the point which I referred to in the beginning, namely, that there is no war between electricity and compressed air and that each has its field of usefulness. This electro-pneumatic system which controls the great Pennsylvania Railroad in its line between New York and Philadelphia, and which may be found in all large railway terminals, represents a community of interests between compressed air and electricity. Wires and air-pipes run side by side, the one to act as the trigger and the other as the power to move the switch and direct the train safely, expeditiously and economically. The air-part of this system, so far as the little cylinder in which is a piston moved by air is concerned would not be an efficient engine if applied to common purposes for which power is used, but when doing its work on the switch of the railroad it is one of the most efficient known. Were this not so, some other means would be employed; and we have in this instance electricity by its side ready to serve the purpose, were it able to do so with equal efficiency.

Improved Methods for Difficult Sub-aqueous Tunneling.

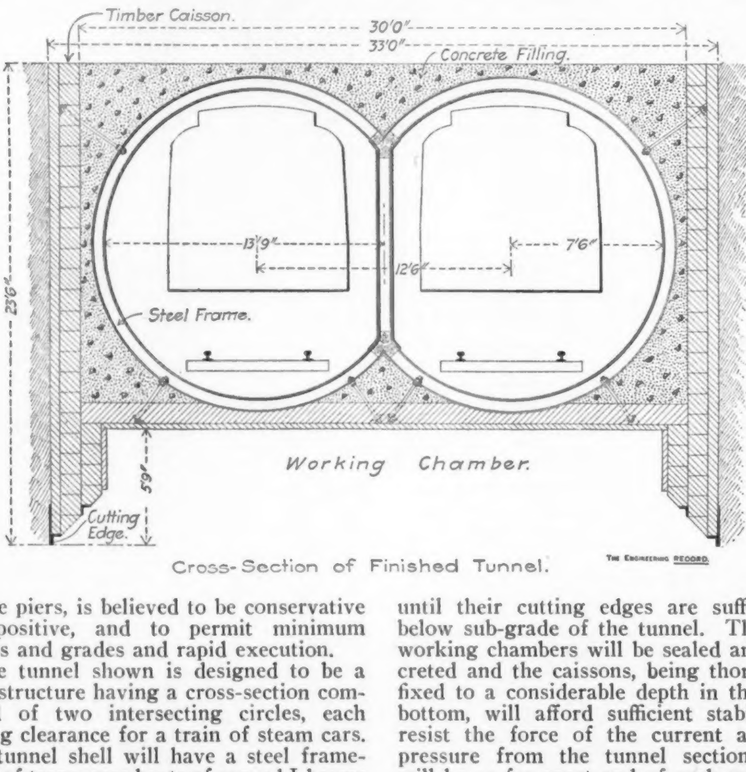
The new transit systems planned for Greater New York involve the construction of a number of very important tunnels under the East and North Rivers, which will have lengths of several thousand feet and dimensions sufficient for one or two railroad trains. These tunnels must be placed at a considerable depth in the ground, involving in some cases great difficulties in construction. In various places they will have to be driven through rock, hard pan, clay, gravel, boulders, sand, mud and very soft silt, and sometimes very dissimilar strata, like rock and silt, will be intersected by the tunnel at the same point. No material obstruction to navigation can be permitted at any time. Where the tunnels cross the rivers the tide has a range of several feet and a maximum current of more than four miles an hour. The ordinary methods of construction will not satisfactorily meet these difficulties.

Recognizing these facts, prominent engineers and contractors have devoted special effort to devising new and improved solutions for the problems of design and construction, which will be applicable to difficult tunnel work in general and, in most cases, suited to the assumed requirements of one or more of the tunnels projected for New York. Several of these plans have had their essential features patented, and have been submitted for consideration in connection with the different projects. While it has not been officially announced that any scheme has been accepted, it is probable that some of the methods suggested may be adopted in the near future, and, as they represent the most advanced thought and careful design of engineers experienced and successful in important constructions, the *Engineering Record* has prepared the following concise descriptions of those plans which have come under its notice.

The system proposed by Mr. John F. O'Rourke, contracting engineer, provides for a finished structure consisting of piers, sunk below the bottom of the river, connected by submerged tubular spans supported uniformly throughout the whole lower surface on the solid bottom, with no projections above the river bottom or obstructions to navigation. The construction will comprise four principal processes:

the construction of temporary working shafts about 500 feet apart in the line of the tunnel; the building on shore, launching and floating to position of sections of the tunnel which will reach from shaft to shaft; the sinking of these sections to sub-grade between the shafts; the alignment and connection of the sections in final position, the removal of the shafts or piers above them, and such back-filling as may be required. The method is a new and ingenious combination of operations and principles which have for years been standard in pneumatic caisson work for bridge piers, is believed to be conservative and positive, and to permit minimum depths and grades and rapid execution.

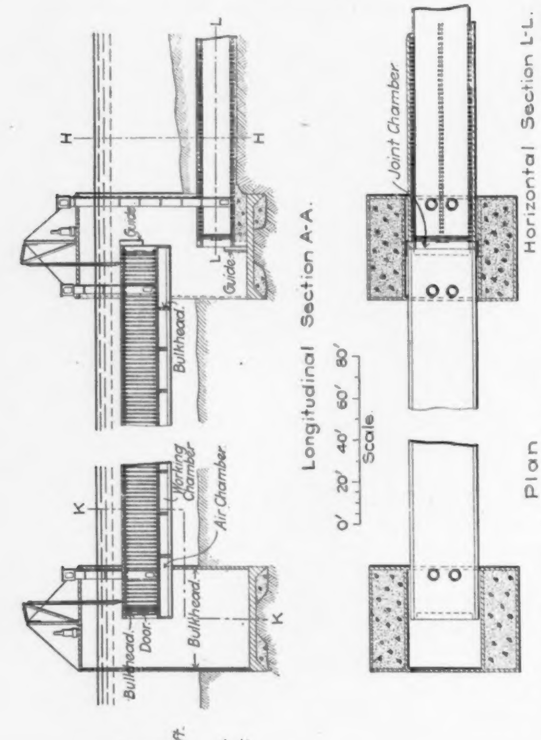
The tunnel shown is designed to be a twin structure having a cross-section composed of two intersecting circles, each having clearance for a train of steam cars. The tunnel shell will have a steel framework of transverse bents of curved I-beams covered with a riveted steel plate and enclosed in a monolithic protecting mass of concrete filled between the steel work and a timber caisson, as shown in the general cross-section. The lower part of the caisson will be decked over solid, and the walls will be extended a few feet below to form the sides of an air-tight working chamber for use in sinking the tunnel. These sections will normally be about 500 feet long, but other lengths may be used when circumstances permit. They will be fully or partly constructed on shore at any convenient place, launched, concreted and towed to position. On the line of the tunnel a trench will be dredged wide enough to receive the tube and extending down to sub-grade, or the sections may be sunk to place by doing all the excavating from the air chamber. Along the center line pneumatic timber caissons about 50x72 feet will be sunk by ordinary methods until their cutting edges are sufficiently below sub-grade of the tunnel. Then the working chambers will be sealed and concreted and the caissons, being thoroughly fixed to a considerable depth in the river bottom, will afford sufficient stability to resist the force of the current and the pressure from the tunnel sections; but will be so far apart and of such moderate dimensions that they will not seriously obstruct navigation. The sides of the caissons, which are transverse to the tunnel axis, will be removable bulkheads easily displaced to allow the ends of the tunnel sections to be inserted through them, as shown in the general plan and elevation.



Cross-Section of Finished Tunnel.

Two adjacent pier caissons having been

sunk and a tunnel section inserted between them, the ends of the tubes will be temporarily closed by bulkheads and the end compartments at least of the working cut away under pneumatic pressure, so as to let the ends of the tubes, which rest between them, sink rapidly under control, the ends being carried on jacks while the



Method of Sinking Caisson Tunnel Sections.

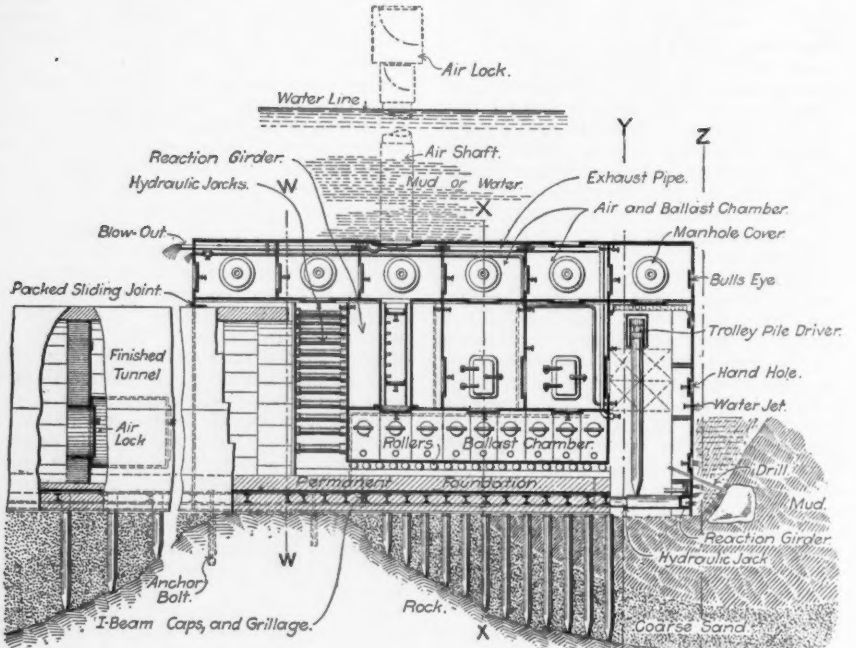
chamber underneath will be filled with air. The buoyancy of the tunnel section will be overcome by admitting sufficient water to the tubes to sink them, and the bulkheads in the sides of the pier caissons will be cutting of the timber proceeds and then lowered at will. When the cutting edge of the tube caisson reaches the bottom of the river, the excavating will be carried on as in ordinary caisson work, and

the tubes will descend under perfect control to their required level or grade, after which the working chamber will be sealed and concreted solid to the deck of the pier caisson and to the bottom of the excavation between piers. A third caisson pier having been placed, another tunnel tube will be floated into position and entered in it and in the second pier, and sunk as already described. Guide pieces will probably be attached to the ends of the tubes so that the second tube will engage the first and be guided to its approximate alignment, where it can easily be closely adjusted by hydraulic jacks or other devices which can move it in any direction while the weight to be overcome will be reduced by the approximate equilibrium between the ballast and the buoyancy. The tube caissons will be fitted with air shafts and air locks at both ends, and the end bulkheads of adjacent sections will be separated a few feet so as to leave small chambers between them which can be pumped out and made accessible for caulking and splicing. In this way the successive lengths of the tunnel between piers can be put in position and finished, after which those portions of the caisson piers which are above the tunnel roof will be detached and removed.

Calculations have been made which, on an assumption of a current of four miles an hour, give an hydraulic pressure of 375 tons against one tunnel section and of 86 tons against one of the caisson piers, making a total transverse pressure of about 460 tons against one pier, which will have a stability due to its own dead weight of 2,500 tons, besides being embedded to a considerable depth in the hard bottom, thus giving it a large factor of safety against overturning under the worst circumstances, when the tunnel tubes are floating at the surface of the river. After completion, the tunnel tubes will have continuous bearings over wide bases, so as to be thoroughly supported and not be in danger of sinking, even on soft material. The steel and concrete construction will have great transverse and longitudinal strength so as to distribute concentrated loads over large areas of the supporting ground, which, it is believed, will have ample bearing power, even if of silt, which, however, is not the case to the same degree in ordinary driven tunnels with cast iron or masonry lining.

A large part of the construction work will be done on shore where the tubes can be made as strong as desired and perfectly water-tight. The sinking will be unrestricted and simple, and air pressure will be used to exclude mud and water in the only perfect way, on horizontal planes. As the construction is independent of a natural roof, the depth and the attendant peril is diminished and the conditions of working are comparatively safe. This method is adapted to construction of pile foundations, where necessary, and provides for separate tunnels, although switches can be arranged to transfer trains if necessary from one tube to the other, and doors can be placed at intervals between the two tubes so that in case of accident, particularly fire in a train, the passengers can escape the flames and deadly fumes by entering the other tube and closing the door. It is not thought that this method will differ much in cost from driven tunnels where conditions are favorable to the latter method. In cases of mixed rock and earth in the same cross-section it is much cheaper, while the time required is less than in either case. The material advantage, however, lies in the stronger tunnel and better grades.

The method of tunnel construction proposed by Mr. Jules Breuchaud, C. E., provides for the preliminary construction of a pile foundation or solid footing in successive portions made just in advance of the tunnel walls and roof and all built within the protection of a shield. This shield, which may be considered as a movable pneumatic caisson, is designed to be sunk at any point in the alignment of the tunnel and to move forward on the natural or artificial bottom of any trench or tunnel, excavating the material in advance. Several shields may be placed at intermediate points, be simultaneously operated so as to construct adjacent sections at the same time, and thus greatly diminish the duration of the work. The shields may move through water, silt or mud while the excavation of soft or hard material progresses on the under side, and are primarily adapted to the construction of tunnels without natural roofs; but they may be modified for the construction of submerged foundations, piers, pipe lines or conduits. The shields are rectangular with vertical sides and ends, horizontal top and rounded corners, and are made with double walls enclosing space around the sides and roof, which is divided into numerous air-tight chambers by transverse vertical and horizontal partition plates. These chambers



Half Section X-X. Half Section W-W. Half Section Y-Y. Half Elevation Z-Z.
Shield Constructing Permanent Tunnel Foundation in Advance.

are connected and are accessible from the interior of the shield by covered manholes and doors, as shown in the sections.

The shield has only four sides, being open at the rear and bottom, and is braced by the interior solid plate diaphragms between the air chambers. Its lower part is an unobstructed working chamber corresponding to that of an ordinary pneumatic caisson. There is a transverse vertical bulkhead near the forward end enclosing a chamber reaching to the roof and affording an unobstructed space for the driving of foundation piles, which may be supported in a traveling carriage, handling also the driving apparatus. The front end of the shield is a solid plate diaphragm, which may be stiffened by longitudinal bracing to the transverse bulkhead, as indicated by dotted lines. It is pierced with horizontal rows of small holes through which pneumatic and hydraulic jets can be played to loosen the material in front. There are other small holes, provided with stuffing boxes, for the insertion of drills to attack rock, boulders, hardpan, etc. Larger holes are also provided and covered with water-tight inside plates, which may be removed to reach external objects.

The excavating jets are supplied by nozzles or flexible connections branched to horizontal pipes running across the inner face of the end of the shield, connected with large mains permanently built into the concrete floor of the tunnel. The compartments in the roof and sides are independent and can be filled with water ballast or emptied by a system of pressure pipes operated from the power plant in the shaft or on shore. The lower chambers in the sides are tapered at the bottom to give more space in the working chamber, and can receive pig iron ballast to increase the stability of the shield. One of the interior center chambers is provided with vertical, telescopic, cylindrical shafts which may be projected through the roof and carried above the surface of the water, so as to terminate there with an air lock and afford independent access. The shield is seated on horizontal transverse rollers under its parallel sides, which take bearing on the tops of special pairs of deep I-beams permanently embedded in the concrete footing of the tunnel. The side plates of the tunnel project below the rollers and enclose the full depth of the sides of the concrete footing, thus guiding the tunnel in its alignment and serving to prevent the escape of compressed air, excepting under the higher front edge where its action would be beneficial rather than harmful in loosening the material about to be excavated.

The longitudinal movement of the shield is effected in the usual way by means of hydraulic jacks placed horizontally to bear between the forward end of the last finished section of tunnel lining and a girder of corresponding outline in the rear of the shield. Besides, there is a horizontal row of jacks in the lower part of the front end of the shield which bear between a girder across the lower edge of the front diaphragm and the end of the completed floor platform. This latter set of screws, not ordinarily used in shields, is designed to give a balanced pressure and provide more regular and positive motion. The rear end of the shield is made to overhang the completed tunnel lining for a considerable distance and to slide upon it with a close joint. In operation the shield may be constructed at any convenient place on shore with a temporary air-tight bulkhead closing the rear end. It may be launched, floated to position and sunk as required, adjusted like a foundation caisson and connected to the end of the tunnel before removing the bulkhead, or the bulkhead may be attached to the walls of a tunnel lining built inside the shield and left to close it while the shield moves forward constructing a section of the tunnel.

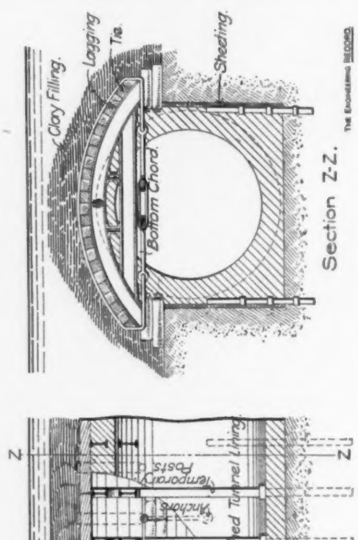
In operation, at any given position, several rows of piles will first be driven inside the shield and capped with a grillage of longitudinal and transverse I-beams filled in with a solid bed of concrete, or the surface of the rock will be prepared to receive the tunnel floor which may be anchor-bolted to it, or the invert may be laid on a bed excavated in hard material. Then a section of the lining for the walls and roof will be built in the rear end of the shield and the material in front excavated through the orifices for that purpose. The jacks will then force the shield forward, another section of the floor and walls will be built, and so on.

Important features of this method are the ability to construct the foundation in advance from within the shield, to use the shield as a pneumatic caisson, and to build sections of the tunnel at intermediate points, and the safety for the workmen afforded by the closed forward end of the shield, which prevents any possible caving

in or entrance of water while the air pressure is maintained. The framework of the shield is rigidly braced with heavy trusses, stiffened by deep flange plates and provided with lateral connections for outside guy lines which may be used to anchor it. The front end is provided with suction pipes through which soft material may be drawn into the shield and with bulls-eyes through which the character of the material in advance may be observed.

A process for building submerged tunnels in open trench through soft earth has been designed by Mr. Jas. C. Meem, who proposes to use a pitched or arched timber roof, built on shore in long sections, launched, floated to position and sunk on to longitudinal foundations previously laid in a dredged trench parallel to the side walls. Underneath this roof the excavation will be made in open trench, suitable foundations constructed and the invert, walls and roof of the tunnel built. The essentials of the process are the special roof and the method of supporting it and excavating and building beneath it. Two types of roof are proposed—one having double pitched I-beam rafters and horizontal cross-beams forming A-shaped trusses, and the other having segmental arch-shaped I-beams with horizontal ties connecting their lower ends, both types being covered with longitudinal timber lagging secured by straps on the upper side which are bent around the lower ends of the rafters and securely joined by tension bars with tightening adjustments. The roof sections are sunk so that their edges rest on the longitudinal walls, preferably built with concrete bags placed by divers. The abutting joints at the adjacent ends are covered with felt or steel aprons and the entire shield is well covered with a bed of clay and sand to exclude water from above and prevent the escape of compressed air from below. At intervals of several sections, short spaces may be left between the ends of the roofs and filled in with solid bulkheads to divide the tunnel into shorter sections, if necessary, for excavation and construction.

If additional stability is required, the roof may be temporarily secured by sinking on it loaded barges. After the roof is in position, excavation is commenced under it and, if necessary, air pressure is used there. The excavation is made in open trench with sheeting and bracing for the sides if necessary. In very soft material, short transverse drifts may be made in advance of the main excavation and sectional pipes sunk in them and filled with concrete to the roof, after which the excavation can be completed in short



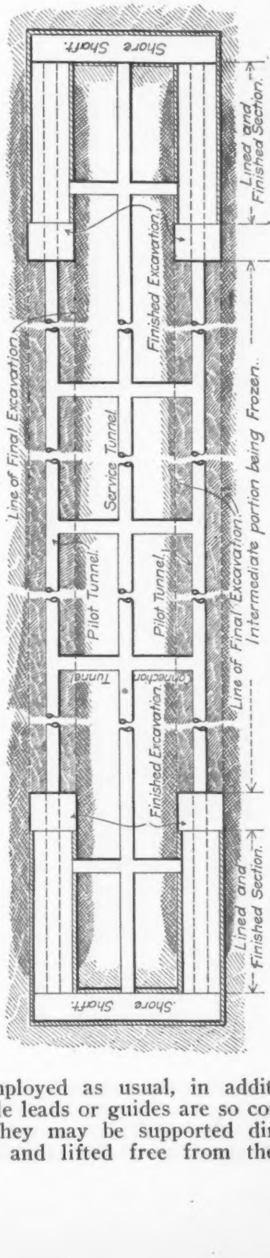
Tunneling under Sectional Roof.

sections and the concrete invert laid and vertical posts set upon it, to which the weight of the roof may be transferred. It is designed to complete the permanent masonry roof arch underneath the roof

shield and to leave the latter permanently above it. In order to anchor the buoyant wooden shield to the heavy tunnel masonry, the middle sections of the horizontal tie-bars may be revolved into vertical positions and built into the side walls, as indicated in the drawings. The method provides for preliminary roof protection, and, while it would be less economical than a shield for sub-aqueous tunneling in ordinary soft ground, the inventor believes that it will be especially suitable where the rock is overlaid with soft material and the tunnel cross-section is intersected by both strata. It is claimed that in a tunnel built by this method the approach grades could be materially lightened because the roof of the tunnel would not have to be depressed below the bottom of the river.

In continuation of the above subject, descriptions of other methods and apparatus which have been designed for such work and are considered applicable to the transit problems similar to those in Greater New York are here presented. Brief reference is made to some important tunnels of recent construction, the descriptions of which it is desired to supplement with others of similar interest and importance. A discussion of such engineering designs and operations is valuable, and fair-minded criticisms are helpful to their projectors. The columns of the *Engineering Record* are open to communications and suggestions concerning them or to descriptions of difficulties and devices developed in similar work.

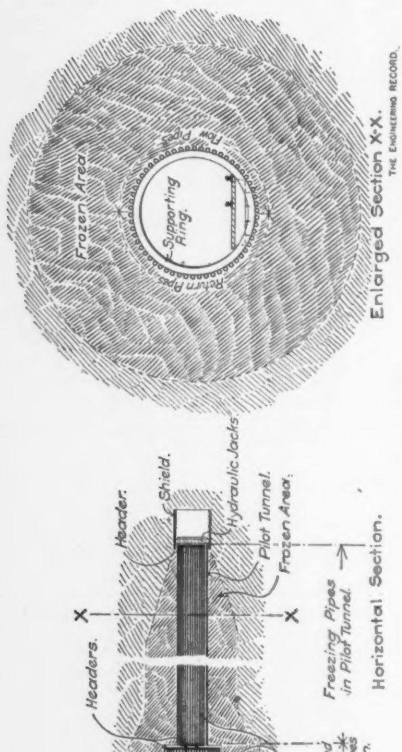
The method proposed by Mr. Charles Sooysmith, C. E., provides for a foundation of piles driven through deep water to support two or more separate or joined parallel tunnels, excavated in very soft, wet material from headings driven from the bottoms of shafts, wholly under the river bed and always retaining a roof of the natural earth above them. Novel features are involved in the driving of the piles to a great depth under water, and in the combination of the freezing method and pilot tunnels for the difficult excavation. The preliminary drawings show a special pile driver carried by two barges held by frames at a fixed distance apart. The multiple leads or guides in the space between the two barges are adjustable in both directions, so that when the barges are anchored in position several rows of piles can be driven without changing their location. Braced guides extend below the barges and through them spuds may be put down to hold the barges in position, and yet leave them free to rise and fall with the tide. Anchors and lines may



ARRANGEMENT OF PILOT TUNNELS AND SHAFTS.

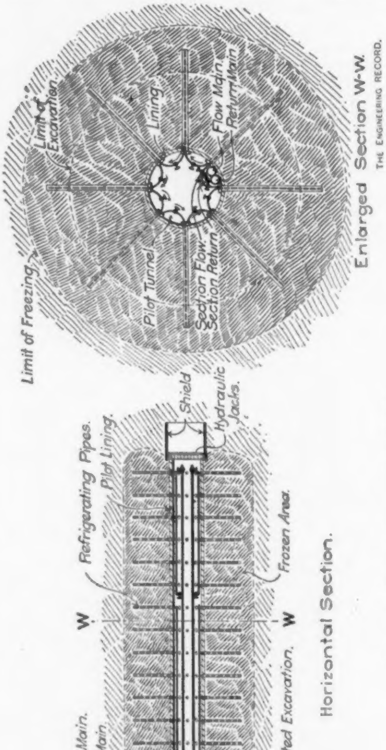
be employed as usual, in addition, and the pile leads or guides are so constructed that they may be supported directly on spuds and lifted free from the barges,

which would then have no connection with them and would serve only as a means of moving the leads to any position as required. Enough leads will be provided to drive several bents of piles without relocation.



LONGITUDINAL REFRIGERATING PIPES.

Before driving each pile, a steel tube somewhat larger than the pile will be driven by hammer or water jet until its bottom is at the level of the bottom of the proposed tunnel; the pile will then be driven through this tube, the length of the pile selected being such as to make it drive to the desired resistance at the bottom of the tube. The pile within the tube will be driven by a Nasmyth steam hammer



RADIAL REFRIGERATING PIPES.

METHOD WITH PILOT TUNNELS AND REFRIGERATION.

pile driver, preferably run by compressed air. This will rest upon the pile and be enclosed in an air-tight shell attached to it, open at the bottom and extending a little below the top of the pile. Air will be kept in this shell to exclude water from it so that the hammer will work as in a diving bell. The use of the guide tube, subsequently withdrawn, will avoid much of the difficulty and friction of driving piles to great depths under water and is intended to promote the rapidity, economy and accuracy of the work.

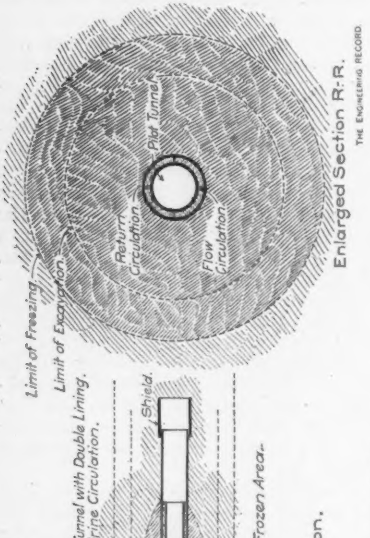
After a foundation has thus been constructed to carry the tunnel and its loads, without danger of settlement or distortion in the soft and treacherous silt, it is proposed to drive a small heading about 7 feet in diameter on the axis of each of the required tunnels. These small headings can be driven without difficulty in the usual way by compressed air, at an estimated speed of 10 feet a day or more and will serve first as refrigeration chambers and afterwards as pilot headings which will be enlarged to the full sized excavation required for the permanent tunnel. As fast as built, the temperature within the pilot tunnels will be reduced to about 10 degrees below zero, by means of pipes laid directly against the soil. Through these pipes there will be a circulation of chloride of calcium brine, cooled by an ice machine outside, precisely as is done in cold storage warehouses. The freezing will continue until the earth is frozen to such thickness that the full sized tunnel can be excavated within the protection of the temporarily hardened walls, or where the time available will not permit the freezing to be done at one operation from the original heading, which would require several months, an enlargement of the pilot tunnel will be made in the frozen material and pipes laid against the new surface so made and the freezing continued. By reason of the increased freezing surface so obtained this will result in an economy in time from freezing the necessary distance outward. Or radial pipes can be pushed outward from the pilot tunnel before freezing and a circulation of cold brine maintained in them. In any event, the working face of the main tunnel would be bulkheaded off from the finished section by a rolling partition, which would prevent circulation of warm air to the pilot tunnel.

Experience has shown that soil so frozen is impervious to water and has great strength. It resembles a dense sandstone and can be worked in much the same manner by blasting or chipping. Tests of frozen silt from the bottom of the Hudson River show it to have a compressive strength of from 400 to 600 pounds per square inch. It is estimated that the walls should be frozen 5 feet outside the line of excavation and that for a 10,000-foot tunnel a refrigerating machine, with a capacity of 525 tons a day, would be required to accomplish the necessary freezing in one year. One of the principal advantages of the freezing method as applied to tunnels is that when the pilot tunnels are constructed and the freezing done the work of constructing the main tunnels can progress rapidly without compressed air, and in a manner permitting the most elaborate supervision and inspection. This is difficult to obtain by any other method. Another advantage claimed is that after it is once established the freezing will be progressive for some time should the refrigerating medium be withdrawn, and that an accident disabling the entire plant for several days would not necessarily cause a disaster to the work.

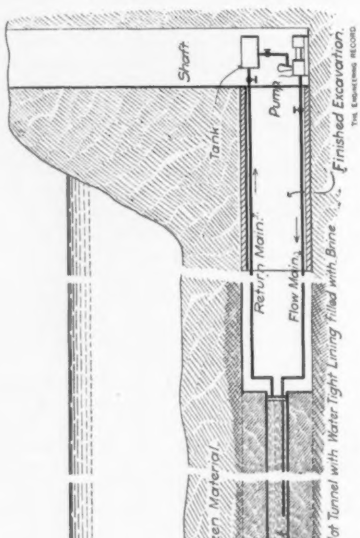
Mr. Sooysmith bases some of his calculations on data afforded by his use of the Poetsch system for sinking difficult shafts by the freezing method at Iron Mountain, as described in the *Engineering Record* of June 14, 1890. These data and other knowledge and experience gained by sinking vertical shafts and excavations by the freezing process enable preliminary estimates to be made which are claimed to be more accurate and less contingent as to time and cost than for other methods, and it is interesting to note that while there is no record of the application of the combination of this system with pilot tunnels, the freezing process has been successfully applied to difficult tunneling as described in the *Engineering Record* of May 6, 1886, where the foot way tunnel in Stockholm was driven with the aid of cold air supplied to the heading.

The general plan of operations includes the initial construction of three parallel 7-foot pilot tunnels in a plane through the axes of the required tunnels. The two outer pilot tunnels will be used for refrigerating galleries and subsequently enlarged to the required cross-section for the permanent tunnels. They will be connected by transverse tunnels about 500 feet apart, so that the center pilot tunnel may be used as a service gallery to expedite the construction of the main tunnels, after which

it may be abandoned or retained for conduits. The pilot tunnel will be driven from shafts at each end, which will be long enough to serve both of the main tunnels, and from these shafts the excavation of the full width will be commenced on both sides of the river while freezing is in progress in the pilot tunnels, as indicated in the general diagram. It is proposed to provide the pilot tunnels with a system of longitudinal pipes laid together around the circumference of the tunnel and supported at suitable intervals on circular ribs. These pipes will be connected at both ends by circular headers in such a manner that half of them will be used for flow and the other half for return pipes, and a constant flow of brine



REFRIGERATING SHELL.



REFRIGERATING TUNNEL.

METHOD WITH PILOT TUNNELS AND REFRIGERATION.

will be maintained through them by means of circulation mains from the shore header to the pump and refrigerating machine. The pipes will be so close together that they will serve as skeleton lagging which, with the air pressure, is expected to exclude the mud; but may be reinforced, if necessary, by inserting short strips of wood between them until the mud is frozen stiff enough to be stable independent of the air pressure.

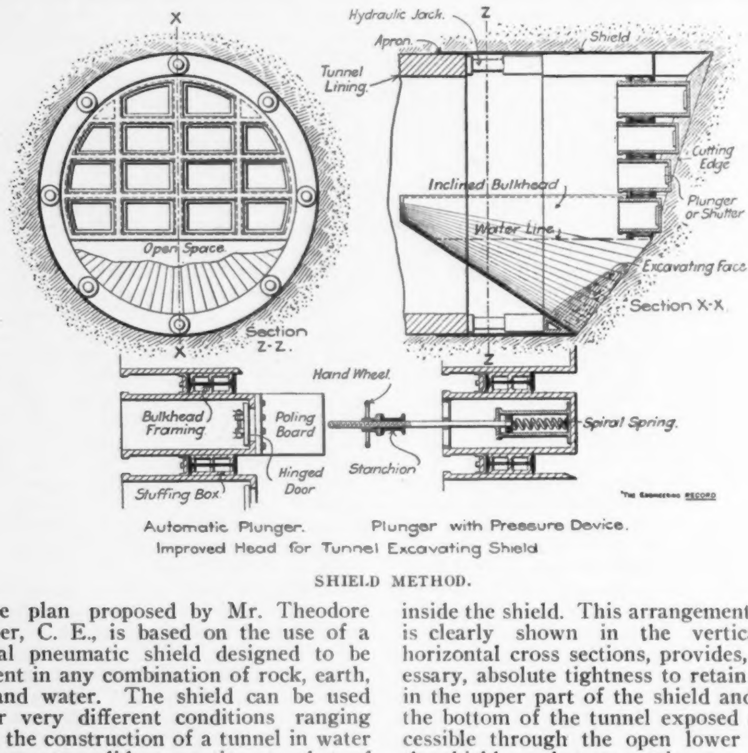
At the ends of the tunnel close to the shaft, it may be desirable to remove these pipes and make a circular excavation about 16 feet in diameter before the ground is frozen to the final limits. In this excavation another set of longitudinal pipes and headers will be placed to freeze the ground to a distance of about 5 feet beyond the limits of the final excavation, about 25 feet in diameter, which can thus be made much more quickly, but less economically, than if the freezing there was entirely accomplished from the original pilot tunnel. This method of successive cuts will only be employed at the beginning of the tunnel to expedite the construction.

As there will be four working headings, the conditions in them may vary, and another system of piping has been devised for use near the shafts where it is necessary to accelerate the freezing as much as possible, so as to be able to commence the construction of the finished tunnel without waiting a long time for freezing to be completed throughout. It is proposed in this case to line the pilot tunnels and to lay in them large longitudinal flow and return mains controlled by gate valves dividing them into sections of perhaps 1,000 feet. From each of these sections several smaller secondary parallel mains, about 100 feet long, will be valved, and from each of them connections will be made with series of radial pipes 11 or 12 feet long driven in sets about 6 feet apart. These pipes will be closed at both ends and will contain a small inner pipe connected with the brine supply and open at the outer end, the return flowing back through the large pipe. These pipes will be connected to each other and to the secondary mains in series by valved lead branches, so that the brine will flow successively through all of them from the supply to the return main, as indicated in the cross-sectional diagram. By this method freezing will be very rapid and can be controlled absolutely or varied at every point, but a very large and costly pipe installation is required. After the materials are satisfactorily frozen, the pipes can be easily withdrawn by first injecting steam, and the holes which remain, and which are shown in the diagram by dotted lines, will be useful for blasting the frozen material.

The most economical method of freezing the main part of the tunnels under the center of the river is believed to be by means of converting the pilot tunnel itself into a single large refrigerating tube, which will effect great economy of pipes and pumping, but will be slower than the process above described and will preclude any extension of the pilot tunnel which is being refrigerated. It is, therefore, proposed to treat only the central part of the tunnel in this manner, while the shore ends are being excavated and lined by methods already described. For this process the pilot tunnel will have a watertight lining closed at both ends with bulkheads through each of which there will be made connections to flow and return mains, the former being extended nearly to the center of the tunnel. The refrigeration plants will be installed at both ends of the tunnel and will, therefore, be enabled to work together on the center section after the headings of the pilot tunnels have met. When the time available is sufficient, as when the pilots have been completed a long distance ahead of the main tunnel construction, the pilot tunnel may be lined with a double shell divided into two parts by radial diaphragms so that the flow and return mains connected at the shore ends would insure a circulation of brine to the inner end and back as indicated in the diagram.

In order to prevent any danger of leakage out of the pipes, the brine will be circulated by pumps located at the foot of the shaft, thus avoiding the head that would be incurred if the mains rose to the surface of the river. The pipes would be subjected externally to the full hydrostatic head of the ground water, so that if there were any leaks in them the flow would tend inwards instead of outwards and no damage would be occasioned. These methods have all been studied and analyzed with great care in reference to the practical results which have been obtained in successful application of the freezing process to very difficult work in this country and abroad, and it is believed by Mr. Sooysmith that the systems here described may, any or all of them, be employed under the conditions obtaining for the tun-

nels that they were designed for, and that they will afford the most safe and desirable method of construction for them. The accompanying illustrations of this process are conventional diagrams intended only to indicate general principles and arrangement, and are in no way definite plans for actual construction. They help explain the methods of application of the freezing process for excavation only; they omit the important pile foundation and all details of design and construction.



Improved Head for Tunnel Excavating Shield

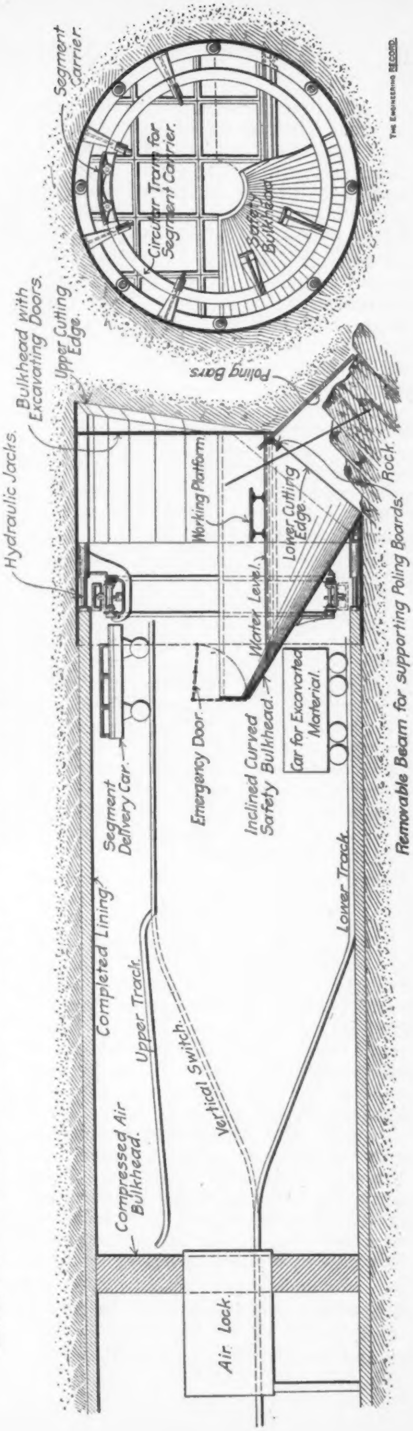
SHIELD METHOD.

The plan proposed by Mr. Theodore Cooper, C. E., is based on the use of a special pneumatic shield designed to be efficient in any combination of rock, earth, silt and water. The shield can be used under very different conditions ranging from the construction of a tunnel in water without any solid excavation, to that of its construction in silt, clay or rock or the construction with the upper and lower parts in different materials. This shield is a pilot of a full cross section of the tunnel, having the usual apron plates which project backwards over the finished tunnel lining and make a close joint with it. The front of the shield is provided with the ordinary slightly inclined cutting edge, and the upper part of it can be entirely closed by removable doors in a vertical transverse bulkhead. The lower part of the cutting edge is inclined backwards and is open, a conical bulkhead being carried from its circumference to a level with the axis of the tunnel and affording a sort of inclined scoop through which access can be had from above to the lower part of the working face, and in which water may rise above the lower edge of the vertical transverse bulkhead in the front of the shield, but will be retained at that level by an adequate pneumatic pressure inside the shield. This arrangement, which is clearly shown in the vertical and horizontal cross sections, provides, if necessary, absolute tightness to retain the air in the upper part of the shield and leaves the bottom of the tunnel exposed and accessible through the open lower end of the shield, so that excavation may be carried on there in the dry under ordinary conditions or at the very worst, if it is impossible to wholly exclude the water, it can only rise to a limited height and excavation may be carried on below its surface. If the material is firm, the doors in the forward bulkhead may be opened and excavation made through the whole face of the shield. If it is very soft, these doors may be closed and the shield may be forced ahead into the unexcavated mass, causing

the latter to flow inward and upward at the bottom through the conical apron around the lower part of the cutting edge, and even deliver itself through its apex into the material cars on the tunnel floor. If excavation is required in the bottom of the tunnel only, inclined poling boards may be driven under the lower edge of the main diaphragm as indicated in the cross section, and rock and other material removed under their shelter, so as to permit the shield to advance. In other cases these temporary poling boards may be driven, leaving the bottom accessible under the inclined cutting edge, so that if necessary sectional piles can be forced down to make a foundation under the tunnel. With the diaphragm doors all closed and the water seal maintained above the lower edge of the main diaphragm, the shield can be pushed forward on the bottom of the river and the tunnel lining built behind it in the usual manner without any excavation or the protection of any natural roof above it.

The design provides for high level and low level tracks connected by a vertical switch. The high level track will be used for bringing segments of the cast iron lining to the crown of the tunnel where they would be delivered to a car operating on a circular track to assemble them in position. The lower track would be used to remove the soil and muck. The connection of the circular track to the moving shield saves a great deal of labor and time in handling the lining segments and enables them to be put in place without interfering in any way with the operations of excavation, thus greatly expediting construction and materially reducing the total expense.

For tunneling through very wet or soft material Mr. Cooper has designed an improvement especially adapted to the shield already described, which is intended to reduce the excavation absolutely to the amount of displacement of the finished tunnel, and thus prevent disturbance of the material pierced or subsidence of the surface and consequent danger to structures above; to facilitate the alignment and diminish the force necessary for driving the shield, to prevent material from caving in and to decrease the danger to workmen. This improvement avoids the necessity of having workmen stationed in advance of the forward bulkhead, or of using a long and unwieldy projecting hood. It consists essentially of forming the forward



Pneumatic Tunnel Shield with Water Seal.

SHIELD METHOD.

bulkhead of independent horizontal hollow plungers. Their outer ends receive most of the horizontal thrust against the end of the shield, and can be set so as to resist the pressure of the earth and water and confine its slope to a required angle.

These plungers are units with dimensions suitable for their convenient operation, and enable the pressures against the outer surface to be advantageously differentiated in accordance with the conditions which vary with their positions. They virtually constitute a series of springs covering the solid face of the end of the shield, which is exposed to unequal pressures, and maintain equilibrium over that portion of the heading which is above the point of excavation. They provide for a constant and regular flow of material into the lower part of the shield where it can be handled and controlled, and permit the intermittent or continuous advance of the shield with a constant regulated pressure on the upper part. As the air pressure in the pneumatic shield is constant, while the external pressure decreases upwards, they can only be balanced at one point and the former is in excess by an amount of 60 pounds per square foot for each foot in height above the level of the water seal. This unbalanced pressure will enable the plungers to be automatically operated in the upper part of the shield, and the lower ones may be provided with special devices for overcoming the friction and increased outside pressure.

The patent drawings show the forward bulkhead extending in a vertical transverse plane to below the seal of the water line in the inclined bulkhead, and composed of a framework of vertical and horizontal I-beams with the spaces between them entirely filled by rectangular plungers working in stuffing boxes. Each of these serves as a movable shutter which is pushed out against the soft earth, and maintained there wholly or in part by the pneumatic pressure in the shield. They may be used with or without pneumatic pressure and with or without water seal and the conical interior bulkhead. In a dry tunnel they may be used to reduce the amount of excavation, and it is believed that in either wet or dry earth they will advantageously replace ordinary poling boards.

The plungers may be open at the inner ends and closed at the outer ends by hinged and latched doors through which material can be removed if necessary, and they may be provided with projecting flaps or fixed iron poling boards to diminish the inward flow when the doors are opened in very soft material. They may also be made, as shown in the detail, with open inner ends and closed outer ends provided with spiral springs enclosed in cylinders which receive a piston head that compresses the spring by a rod commanded by a nut and hand wheel arranged inside the shield, so as to enable the plunger to be set in any required position and adjust itself to the variable pressure.

The plungers may be advanced with the shield or independently of it, or may be allowed to recede or remain stationary when the shield is advanced by the usual method, thus materially facilitating the manipulation of the shield and permitting its cutting edge to penetrate the soil with decreased expenditure of force. They afford an elastic resistance to the soil and enable any portion of it to be separately treated and all portions of it to be put under special or automatic uniform or varied pressure, while the excavation may be absolutely confined to the lower part of the shield under the water seal and governed to correspond with the definite slope of the material for the actual displacement of the shield.—*Engineering Record.*

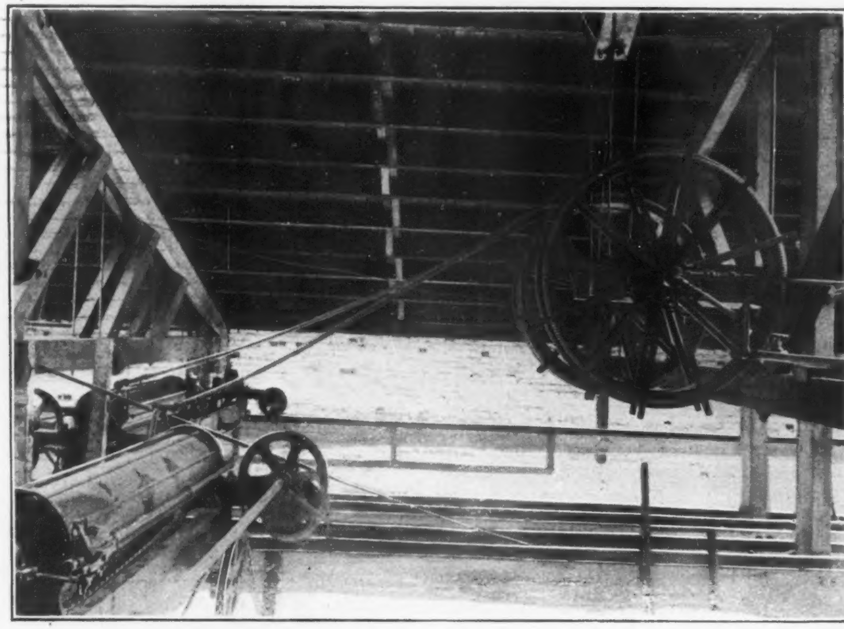
Hose-Reel for Pneumatic Cranes.

The object of this device is to provide a means for properly paying out the hose as the crane moves toward either end of its track and automatically rewinding the hose as the crane moves from either end of the track toward a point about midway the length of the same.

In its preferred form the invention consists of a reel, journaled at a suitable point above the rails of the crane and at a suitable point, preferably midway, between the opposite ends of the track. Wound on this reel is the supply-hose, one end of which is passed through an opening in the periphery of the reel and connected to a nipple of the coupling connecting the hose to the stationary supply-pipe. The nipple is connected to a tube, which is nicely fitted on the projecting end of the reel-shaft, said shaft being hollowed out axially at this axial chamber being in constant communication with an

annular chamber, formed interiorly of the tube about midway its ends and in communication with the lateral branch or nipple by means of a series of radial passages. Packing-rings and glands, screwed on the ends of tube, form stuffing-boxes which prevent the escape of air at the ends of said tube. This coupling permits the inner end of the hose to revolve with the reel and at all times in communication with the supply-pipe, as is evident. The other end of the hose is connected to the inlet-pipe of the crane-cylinder by a similar coupling. The hose is connected to a nipple, which is formed integral with a tube, surrounding the perforated horizontal portion of the inlet-pipe, this tube being internally chambered and having its end portions nicely fitted on said tube. A cap is fitted on the end of the tube, this cap fitting in a socket formed in the end of the tube and being held therein by means of a screw-cap. Another screw-cap is screwed on the other end of tube, and a suitable packing may be incased by this cap to form an air-tight joint. With a coupling of this sort it will be observed that the end of the tube will have a swivel-like connection to the supply-tube.

It will be observed that as the crane moves out toward either end of its track the hose will automatically unwind, and to prevent the hose sagging below the track-beams journal on posts rising at intervals along the same, above the rails, supporting rollers or pulleys, on which the hose will rest as the crane moves outward and from which the hose will be picked up as the crane moves toward the reel. To automatically thus pick up the surplus hose as the crane moves toward the reel, a weight is provided, which is connected to a rope or cable, extending up through pulleys, depending from suitable beams above the reel, and then down to and around a small drum, attached to the reel at the side opposite the coupling. This counterweight is of just sufficient weight to automatically rewind the surplus hose as the crane-carriage moves toward the reel from either end of the track, but not sufficient to exert a pull upon the carriage.



HOSE-REEL FOR PNEUMATIC CRANES.

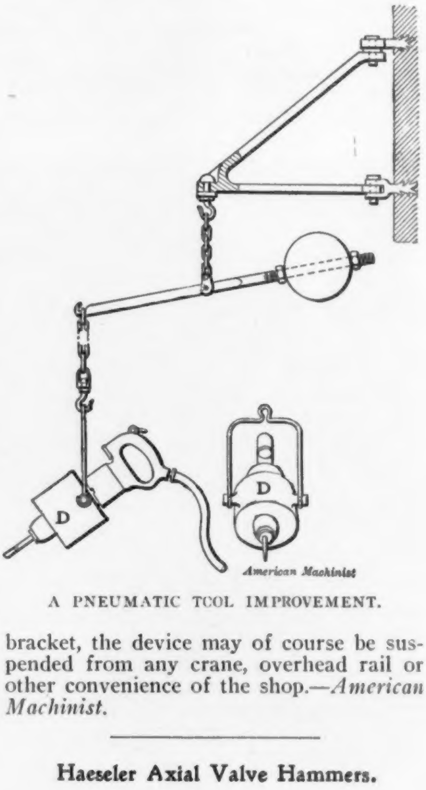
The rollers or pulleys are supported slightly below the line of travel of the horizontal part of the inlet-pipe, so that as the carriage moves away from the reel the hose will be deposited on the rollers and be thereby prevented from unduly sagging, and when the carriage moves toward the reel the hose will be lifted off the rollers in succession. To the left of the reel a roller or pulley is journaled just above the line of travel of the hose, so that when the carriage moves out on the track to the left of the reel the hose will engage under this pulley and be held down on the rollers without impeding the free passage of the hose.

It will be observed that the swivel connection between the hose and the inlet-pipe of the crane permits the crane to move freely backward and forward under the reel without twisting the hose, and it will also be observed that by locating the reel above the track and at a point midway of the ends of the same it will be necessary to employ hose of a length simply equal to half the length of the travel of the crane.

It is obvious that this device is not confined to compressed-air cranes, but is applicable to any apparatus where a flexible tubing may be employed to supply fluid to a movable carriage and where it is desirable that the tubing shall be automatically paid out and rewound as the carriage moves away from or toward the reel, which device has been patented by Mr. Henry H. Sullings, of Huntington, West Virginia.

Something New.

The cut herewith, from a recent patent by F. M. Leavitt, of Brooklyn, N. Y., combines two suggested improvements in the use of pneumatic hammers, riveters, caulkers and tools of that type. Those familiar with these tools need not be told that the jar or vibration of the tool is a very serious matter to the workman who manipulates it for a considerable time, and the device of Mr. Leavitt is primarily to minimize this objectionable feature. This is done by increasing the mass of the hammer case, a heavy weight *D* being attached to or made integral with the normal case of the tool. It goes without saying that this increase of weight must and does reduce the jar. The increase of weight necessitates some means of supporting it, and this has led to the suspension device here shown, by which the weight is perfectly balanced, enabling the tool to be moved about with great ease. Instead of the fixed



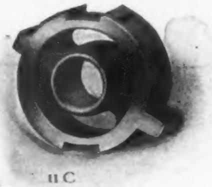
A PNEUMATIC TOOL IMPROVEMENT.

bracket, the device may of course be suspended from any crane, overhead rail or other convenience of the shop.—*American Machinist.*

Haeseler Axial Valve Hammers.

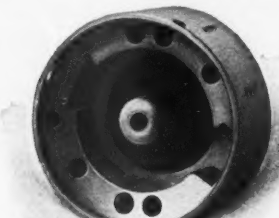
We call attention to a new form of Pneumatic Hammer recently introduced by The Ingersoll-Sergeant Drill Co. It is claimed that the highest degree of excellence yet attained in pneumatic hammers is represented by these tools. The features of marked improvement, as compared with other pneumatic hammers, are the valve mechanism for reciprocating the piston, a locking device for taking up wear and securely locking the handle, valve box and cylinder of the tool together, and a simple arrangement of throttle valve for controlling the admission of the air supply.

The valve is a radical departure from the various forms of straight-line reciprocating valves ordinarily used. Its strength of construction, steadiness in action and freedom from wear overcomes the recognized defects in valves heretofore employed in connection with other pneumatic hammers. As its name, "AXIAL VALVE," implies, its movement is around a fixed axis or trunnion, the travel forward and back, to alternately open and close the admission and exhaust ports, being caused by a constant air pressure upon the short wing or projection of the valve and intermittent air pressure upon the long wing.



11 C

AXIAL VALVE.



11 B

INTERIOR OF VALVE BOX.

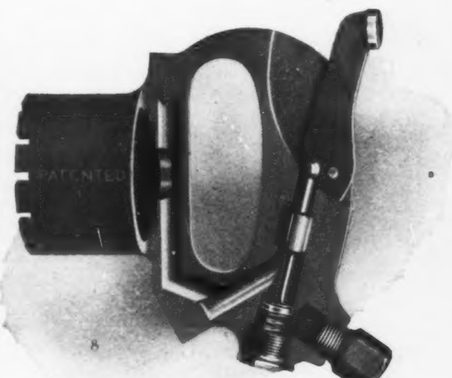
The ports in the valve, as well as those in the valve box, are relatively of equal areas, and are located diametrically opposite to each other, so that any pressure against either side of the valve is equalized by a corresponding pressure upon the other side, resulting in a balanced valve and consequent absence of friction and wear on the trunnion or axis about which the valve moves.

As the movement of the valve is transverse to the direction of the travel of the hammer or piston, the vibration of the entire tool is lessened in operation, and the action of the valve is not disturbed when the hammer blow is struck, but is quick, steady and uniform, and entirely free from fluttering or incomplete travel common with valves moving in line with the piston.

The valve is steel, drop forged from selected stock, is hardened, accurately ground to gauges, interchangeable, and guaranteed against any breakage from service.

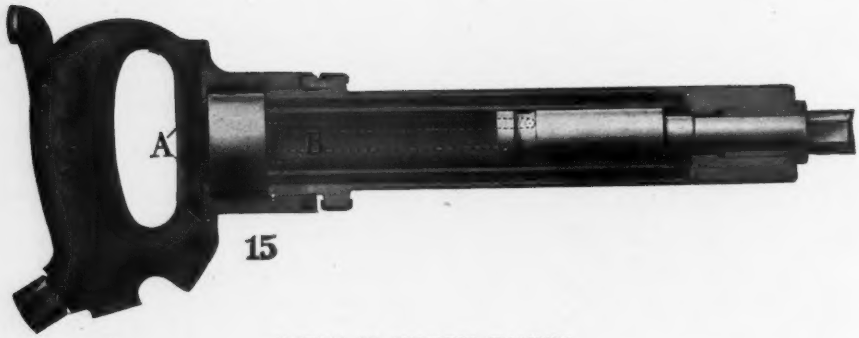
The valve box is also made of steel throughout, with all surfaces ground.

The efficiency of a pneumatic hammer is seriously impaired if the joints between the faces of the cylinder, valve box and handle are not kept tight. See A and B on cut.



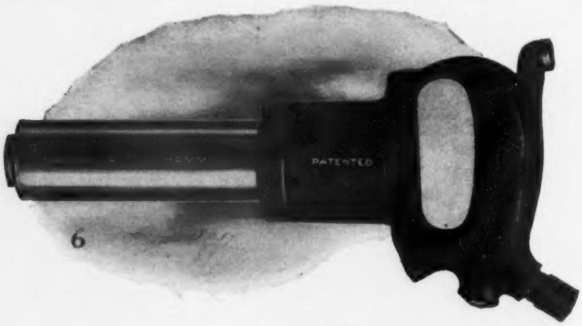
THROTTLE VALVE—CLOSED.

To insure keeping these joints tight, by securely locking the parts together, we have provided a simple and strong construction, consisting of a number of slots in the collar of the cylinder and a different number of notches in the end of the handle, the one number not being a multiple of the other. This arrangement permits a fine adjustment to be made when it is desired to take up the wear of the parts, as a notch in the handle will always be in line with one of the slots in the cylinder, without regard to any required position of the handle being necessary.



SECTION OF CHIPPING HAMMER.

When the handle is screwed up tight, the parts are locked together by a key being inserted in the registering slot and notch referred to, and this key is held in place by a spring band being snapped over it and around the collar of the cylinder.



CHIPPING HAMMER.

Haeseler-Ingersoll Chipping Hammers are made in five standard sizes with the symbols 1-H, 2-H, 3-H, 4-H and 5-H, the figures in each instance referring to the length of stroke. The Long Stroke Riveting Hammers are built in sizes 6-H, 8-H and 9-H.

RIVETING HAMMER.

A Suspended Tunnel.

Mr. J. S. Parmenter, of Woodstock, Ontario, Canada, writes the *Scientific American* as follows:

Three methods have been suggested lately in many of the scientific papers for the support or foundations of the proposed North and East River tunnels of the Pennsylvania Railroad Company. In my opinion, there are serious objections to each of these plans.

The one proposed by Mr. Jacobs, the railroad company's engineer, is, if I understand it correctly, simply a girder bridge of several spans incased in a tunnel with foundations at each span reaching down to bed-rock The inclosing of these girders inside the tunnel makes it necessary to build the tunnel of very large outside diameter, which fact makes it very difficult of construction and *very costly*.

Mr. Sooysmith's plan of freezing the silt is, I believe, too much of an experimental nature, as yet, for tunneling to warrant its adoption in an undertaking of this magnitude. The adoption of Mr. Sooysmith's plan of driving piles throughout the whole length of the tunnel would certainly disturb the silt through which the tunnel would have to be pushed, to such an extent that in all probability it would be of the consistency of builder's mortar, and consequently very difficult to tunnel through.

As to Mr. Reno's plan of pushing the tunnel in the usual way by means of a shield, and the use of compressed air, I believe it to be the correct way; but as to his method of providing a foundation for the tunnel, I cannot approve, for the reason that the solidity of the concrete foundation would depend entirely upon the solidity of the silt or other material upon which the concrete rested. Consequently, it seems to me it would be quite unsafe to rely upon a foundation of this nature.

With your permission, I will suggest a plan for supporting these tunnels, entirelv different from either of the above named. I would suggest that the tunnels be built in the usual way, as Mr. Reno suggests, bv the use of a shield and compressed air, and that at each end of the tunnels, as close to the water's edge as possible, a substantial foundation be built upon the bedrock, and of sufficient height to reach about half way up the tunnels at each side. These foundations are for the purpose of supporting wire cables, which would run through the inside of the tunnels, one at each side, and securely fastened thereto and anchored at each end, as in those of any large suspension bridge. From these two cables the car tracks would be suspended. This method of suspending the tunnels on wire cables would effect a very large saving, as the diameter of the tunnel could be much less than those containing bridge girders. It could also be built in much less time than either of the three plans above mentioned, as the tunnel and the cable foundations could be proceeded with simultaneously.

Gold Mining in Wales.*

Five miles northwesterly from Dolgelley, Wales, the gold mine Colgan, or St. David, is situated. Mining in the Colgan Mountains is supposed to have been carried on by the Romans, if not, indeed, started by them. It is now managed by a company formed in "Barmouth," whose mill buildings are modern framed corrugated iron structures, neat and sufficient—not extravagant.

In seasonable weather, which means wet weather to the gold miller, all the plant is run by water power, with a Pelton wheel of 190 H. P. under a head of 200 feet of water, piped from a distant reservoir. In the absence of sufficient water, a Tangye producer gas plant is used.

There is also a compound steam engine to drive compound air compressors when water is short. These were supplied by the Tuckingmill Foundry Company, of Camborne. Air is compressed to eighty pounds pressure for rock drills and air winches, the former supplied by the Tuckingmill Company and the latter by Holmans, of Camborne.

Ore is obtained by means of compressed air rock drills, which drill holes to a depth of about five feet in the working face. In each hole are placed one to six dynamite cartridges, and each explosion brings down from five to six hundredweight of quartz. The firing of a shot in a mine sets the air in the galleries into vibration, as though the gallery were a long organ pipe, extinguishing lights and giving, in addition

* Abstract from an article by W. H. Booth, in *Cassier's Magazine.*

to the sharp report of the explosion, a low note, which is very startling, as it comes unexpectedly.

At the Voel Mine, near by, a compound air compressor and compound steam engine to drive sixteen rock drills was installed by the Tuckingmill and Foundry Co., who also furnished the rock drills.

The compressor house is some distance from the mill, and air is carried round to the mine by pipes, with a second large air receiver at a considerable distance from the compressor. This helps to maintain the pressure at the more distant points and equalizes the flow of air in the pipes.

The third of these gold mines is the "Gwyn-Fynydd," on the Mawddach. The air compressor used there is of single-cylinder type, and is driven by a turbine, to which water is piped from a point about half a mile away at a head of 170 feet. Failing water, there is a steam engine as a reserve.

Powerful Air Compressors.

"During a recent visit to Messrs. Walker Bros.' works at Wigan, England," the *Iron and Coal Trade Review* writes, "we inspected large air compressors approaching completion for collieries and mines at home and abroad. One installation, for South Africa, was composed of two complete pairs of compressors. In this case the low pressure steam cylinders were 64 in. diameter, and the air cylinders 58 in. diameter. Steam pressure was 140 lb. per square inch. Air pressure 100 lb. per square inch.

"We saw many other large compressors in course of construction. Messrs. Walker informed us that they had recently supplied to the Cordova Exploration Company for a mine in Canada, compound-compressors driven by a turbine of 1,000 horse power.

"The power from the turbine, in this case, is transmitted to the drum on the crank shaft of the compressors by 30 cotton ropes, 1¾ in. diameter. The compressed air is led for a distance of about three miles in wrought steel pipes, 12 in. diameter.

"The loss in transmission, so far as at present ascertained, is not more than 3 per cent. One important feature of this installation is the employment of an 'After Cooler,' which is placed near the compressors for extracting the moisture from the air before it enters the main pipe line.

"The compressed air is delivered at the mine in a very dry condition, and very free from moisture. Re-heaters are used at the mine for heating the air before being used. The whole plant, consisting of hoisting engines, pumps, stationary engines for driving the stamp mill, machine shops, etc., as well as the rock drills, are entirely operated by compressed air. The capacity of the compressors is about 5,600 cubic feet of free air per minute, compressed to 100 lb. (about) per square inch."

The Weiss Valve for Air Compressors.

The Weiss valve was patented by Mr. F. J. Weiss in 1893, and is suitable for use for air compressors, vacuum pumps, and is applicable to distributing valves for steam engines. It is more especially largely used for the first, or air compressors, on the continent.

The Weiss valve is chiefly designed to give in a rapid manner a large port opening to the suction. It acts in a manner somewhat similar to that of a "trick" slide valve, that is to say, two passages are provided for the air. There are also two cut-off suction edges which close simultaneously. The internal lap of the outer casing of the valve is not quite sufficient to cover the outer ports, at such time as the valve is in its central position. From the above it will be obvious that both ends of the cylinder will be simultaneously in communication the one with the other, for a short time, as the slide valve is at that time moving at its highest rate of speed.

The above action is necessary owing to the fact that the clearance space in air compressors is reduced to a minimum so as to give the highest possible displacement capacity, which latter in some cases is as high as 95 per cent. of the theoretical displacement, and, directly the slide valve closes or shuts off the delivery of compressed air, the occurrence of an excessive amount of compression, is prevented by the air passing, as above mentioned, to the other side of the piston.

It is claimed by makers as an advantage of the slide valve for air compressors that they can be run at a greater speed than is the case with spring-actuated closing valves, but there are, nevertheless, some

compressors in the market which are intended to run at as high a speed as 400 revolutions per minute in the case of those of small size, although they are fitted with spring-actuated closing valves.—*The Refrigerating Engineer.*

Compressed Air in House Heating.

A young man in Virginia has patented and capitalized an invention in house heating which, if it works to his expectation, will be revolutionary. He proposes to heat buildings by means of compressed air, and subsequently use this compressed air to cool the refrigerator and perform other functions for which ice is now required. That he can do all he promises is undoubtedly true, but some doubt is natural in the circumstances that he can do it profitably with present facilities. The best net result in fuel utilization with boiler, engine and compressor is to account for about 9 per cent. of the British thermal units in coal, which would seem to be far below the efficiency of the ordinary stove. To give out the amount of heat which could be had by the direct combustion of 12 tons of coal probably 125 tons would be required if the medium was compressed air. Evidently the inventor has been told this or something like it, for he proposes to compress the air by hand and has included a pump in his patent combination. This, however, does not seem to help the matter any. A man can develop the greatest number of foot pounds of which he is capable in the treadmill, consequently the treadmill would seem to be the most effective mechanism for actuating the pump. By this means an average man can develop an energy equivalent to 2,000,000 foot pounds per day. One heat unit is equivalent to 778 foot pounds. A pound of anthracite yields in complete combustion about 13,000 British thermal units, or the equivalent of 10,000,000 foot pounds. From this it would appear that 1 pound of coal contains as much energy available in heating as five men can exert in a day on a treadmill. Twelve tons of coal distributed over six months of cold weather when heating is necessary would be an allowance of 5½ pounds per hour, which would be equivalent to the continuous work of 275 men on a treadmill. This is confusing.

We should also take account of occasional "cold snaps," when comfort might require the consumption of say 12 pounds of coal per hour to keep the house warm. To develop the equivalent of this we should have to keep 600 men on the treadmill.

It would probably be necessary to square things with the union by conceding the eight-hour day; and as the work must be continuous we should need three shifts, employing altogether 1,800 men. This would involve a considerable pay roll. The difficulty is not insuperable, of course, but it may operate to discourage the adoption of the compressed air heating method. The possibility of a strike is always imminent, and treadmill wages would need to be well up to the prevailing rate to be attractive. Everything considered, perhaps power compression would be cheaper and more generally satisfactory.

Another opportunity for captious objection is found in what would appear to be the difficulty in expanding the air again without lowering the temperature of the whole county and inviting restraint by injunction. In conjunction with an ice factory or a cold storage warehouse it might work very well, but such an establishment could scarcely be considered practical as an adjunct to a domestic heating plant.—*Metal Worker.*

Cleaning Carpets with Compressed Air.

The Denver Compressed Air Carpet and Mattress Renovating Works in 1880 brought to Denver from the East the first

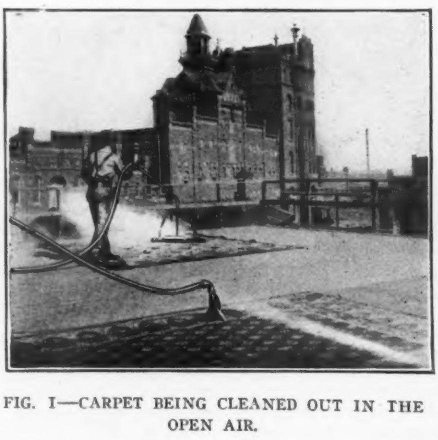


FIG. 1—CARPET BEING CLEANED OUT IN THE OPEN AIR.

carpet-cleaning machine. This was a beater and brush machine. Several years afterward they adopted the now commonly used and so-called tumbler machines (carpet cleaners), of which they had three in use.

Experience combined with careful study has brought about evolution in the line

FIG. 2—AFTER CARPET HAS BEEN CLEANED OF MOST OF THE DUST.

of renovating work as it does in all other things. After much investigation and many trials they came to the conclusion that there is nothing so harmless and at the same time effective as compressed air in extracting dust and renovating of carpets and hair mattresses (see Figs. 1, 2, 3).

FIG. 3—CLEANING WITH OPEN NOZZLEMAN.

This company does not think that carpets can be as thoroughly cleaned while on the floor as they can be if taken up and sent to a cleaning establishment. They compare it to the laundrying of one's clothes, and assert that a "man's shirt cannot be cleaned satisfactorily while it is still on his back."

The cuts give a fair idea of the process as employed in this case. Fig. 1 shows the carpet being cleaned out in the open air; Fig. 2 after it has been cleaned of most of the dust. In Fig. 3 an open nozzleman is used, on a screen floor lifted about five feet from the flat roof, thus giving the air a chance to take off the dust above and below while cleaning. In addition to the open roof is a room with two large Blackman fans, also provided with a screen floor, which is used in bad weather. In this work it has been found that air at from 100 to 120 pounds pressure and a 1-64-inch nozzle gives the best results.

Pneumatic Appliances.

The Northern Engineering Works, Detroit, Mich., are manufacturers of the Champion air hoist shown in Fig. 1. They

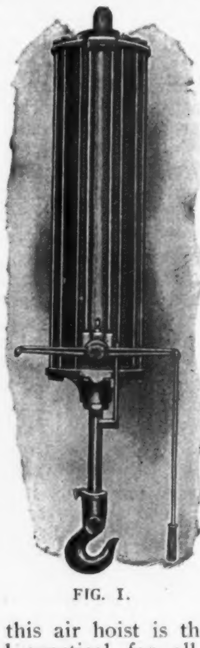


FIG. I.

claim that this air hoist is the most advanced and practical for all classes of

service to which air hoists are suitable, from the most delicate to the most severe. They claim that its special features are all of real and practical value in actual service, and are not simply theoretical. It is economical in air consumption. It is accessible and simple. It is automatic both in lifting and in closing valve. It is safe. It is self-cleaning and self-oiling. It is adjustable both as to speed and lift. It is cushioned. It is high-grade throughout.

This hoist has an improved adjustable valve, combining in one body the inlet and

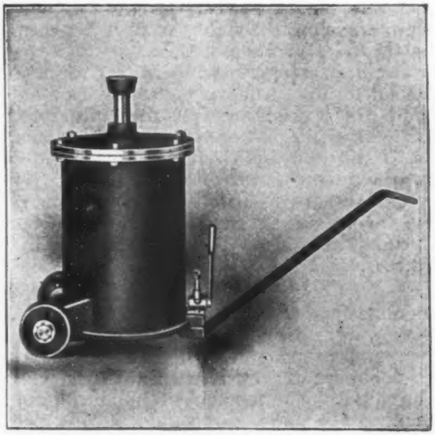


FIG. 2.

exhaust functions, the speed adjustment, cut-off and the safety check.

Fig. 2 illustrates the compressed air jack for short lifting around car and repair shops, as well as in general manufacturing shops. These appliances are in extensive use, and are of great convenience. An extra large piston rod or plunger is used. The standard lift is one foot, but this may be readily increased or decreased to suit conditions.

The Northern Engineering Works build a variety of these, including truck jacks and pull down jacks. They also make a pit truck jack for lifting wheels and axles in car shops.

Notes.

A locomotive on the Chicago, Burlington & Quincy Railway has been fitted with a device for shaking the grates by pneumatic means.

On the Bessemer and Lake Erie Railroad, near Greenville, Pa., an air blast track tamping apparatus is being used on a section of track laid with steel ties.

A Pneumatic Separator Company has been organized at Elgin, Ill., with a capital of $115,000, the incorporators of which are Henry Schmitt, Raymond Schlager and Edward Keogh.

The Pennsylvania Railroad is making trial of a new air brake device in the nature of a pressure retaining system, which is the invention of a New York man and which is said to be giving good results on Altoona mountain.

The Rand Drill Co., 128 Broadway, N. Y., have recently issued the *Imperial Pneumatic Tool Circular No. 2*, describing their chipping hammer, long stroke riveters, piston air drill, air motor hoist, drift bolt driver and all their many different types of air appliances.

Through the recent death of her father, Miss E. F. Jones has assumed active charge of the Preble Machine Works in Chicago. The shop does considerable marine and contract work. Miss Jones recently completed a two years' course in mechanical engineering, and assumed charge of the shop six weeks ago.

The Lidgerwood Manufacturing Company, of New York City, which has large contracts for Brazil, has let an order for an electric-lighting outfit for Manaos, Brazil, to include an engine built by the Harrisburg Foundry and Machine Works, of Harrisburg, Pa. The generator will be of Westinghouse manufacture.

It is with much pleasure and interest that we read carefully the little bulletin just received from the University of Wisconsin, Madison, Wis., describing in full their six weeks' summer school for artisans, the entire cost of which schooling and living combined seem very reasonable.

Catalogues will be sent on application describing in detail the various branches of study, which comprise, among others, courses in heat, steam, gas and other heat engines; also courses in electricity, fuels, lubricants, etc.

The applications of electricity in mines have hitherto been limited for the most part to the distribution of energy to machines in the mines, the necessity in such cases for a power transmission of some kind making electric transmission, with its high economy and its ease of installation, extremely desirable. Its introduction for this purpose has, however, been hindered by fear of utilizing it in fiery mines and by the good work done by compressed-air motors, which have often rendered possible the employment of existing compression plant.

The Philadelphia Pneumatic Tool Company has secured a contract from the Lake Shore and Michigan Southern Railway Company to supply them with all the pneumatic hammers which they will use in the new Collinwood shops and on the entire system for a period of one year. This contract is awarded after a competitive test of all the different makes of pneumatic tools. This company has also received large orders for chipping and riveting hammers and drills from the Wabash, the Delaware and Hudson and the Central of New Jersey railroads.

The Carbon Limestone Co. have recently made initial tests of a new Ingersoll-Sergeant air-compressor drilling machine, capable of operating twenty-five drills. At the company's quarries is being installed a third crushing plant, which will increase the daily capacity of concrete limestone railroad ballast to 1,200 tons of material, ranging from ½-inch to 2½-inch ballast. This in addition to 2,000 tons of furnace stone. The Carbon Company is now filling an order for 100,000 tons of such ballast for the P. & L. E. for use on the four-track system between Pittsburg and the Valleys.

It is reported that Secretary Shaw is figuring with the owners of a pneumatic tube system, who propose to connect the Treasury Department at Washington with its various branches, including the bureau of engraving and printing. Secretary Shaw recognizes the possible value of such a system, and has requested that estimates be furnished him of the cost of a system connecting the Treasury and the bureau. If the estimate is not too high Secretary Shaw may submit it to Congress with a recommendation that an appropriation be made to install a system. In the meantime he is going to consider the practicability of the plan and all the questions arising out of it.

Should Calais, France, and Dover, England, be joined together by a pneumatic postal tube beneath the channel, then a new service may be added to the twentieth century wonders in the form of little trains each carrying, say, twenty people, who will begin traveling through the tubes between Calais and Dover.

These passengers will lie luxuriously extended on "sofa-cars," so as not to bump their heads against the ceiling of the great tubes. They will cross the channel comfortably in twenty minutes, without the slightest fear of sea sickness.

It is anticipated that English patriotism will make no effective objection, if the splendid innovation be brought about by degrees.

Our attention is again called to an explosion in an Illinois coal mine, killing six men and injuring five others. We have no doubt whatever but what this accident was caused by an insufficient amount of air being in the mine at the time of this explosion.

People persist in using electricity for operating machinery in mines when it is a well-known fact that fire damp and other gases prevail in coal mines. Compressed air can be used to do the same work (with the exception of lighting), never at a greater cost and in most cases reducing the expense considerably and at the same time furnishing a large amount of pure air in the mines.

Freezing treacherous earth by artificial process in order to cut tunnels through it is a development of modern engineering that should excite popular interest to an unusual degree. This freezing process is said to have been employed successfully in numerous difficult excavations in Europe. It was applied to the sinking of a shaft at the Chapin iron mine at Iron Mountain, Michigan, where a cylinder of

water-bearing strata fifty-four feet in diameter and extending 100 feet below water level was first frozen, and the perpendicular tunnel then excavated through it. The freezing was accomplished by sinking vertical pipes arranged in a circle around the site of the shaft. Through a smaller pipe in each of these was circulated brine, cooled in an ice machine to zero temperature until the mass was frozen.

One of the unique uses to which the compressed air is put at the Brightwood shops of the Cleveland, Cincinnati, Chicago and St. Louis Railroad is in the operation of the letter presses. Those presses are surely the materialization of the dreams of a lazy man. All that is necessary is to place the copying-book in the press, turn the handle of a stop-cock and the bottom of the press raises leisurely and squeezes that book like no other power on earth could. The mechanism is simple—just a cylinder beneath the press, equipped with a close-fitting piston. When the air is admitted to the cylinder the piston is raised, the bottom of the press is pushed up and something has to give.

The farthest point to which the compressed air is sent from its engine is about 900 feet, but even at that distance it loses only three or four pounds of its pressure.

The efficiency of compressed-air plants can be greatly increased by reheating. The gains are both direct and indirect. The chief direct gain is in the greatly increased efficiency of fuel used in the heating stoves as compared with the effect when coal is burned under boilers. It is commonly stated, and the statement is fairly correct, that when one pound of coal is burned in a reheater stove the commercial effect is as great as when three pounds are burned under a boiler. The increase in commercial efficiency when reheating air from 60° to 400° F. may be put at 35 per cent. The indirect gains are: 1. Better lubrication of the compressed-air engine. 2. Less investment required as a smaller plant will be required. 3. Reduction of compressor-engine friction as compared with the useful work done. In the next few years we hope to see all mines using compressed air have reheater stoves.

An exhibition of a new invention for providing a means of escape from high buildings when on fire was given by John Connett in San Francisco, Cal., the other day. In the short space of two minutes and forty-one seconds the inventor succeeded in throwing three lines from the street on to the roof of the Chief Secretary's office, a height of 101 feet. The lines are wound round a "messenger" and inclosed in a paper wrappage. This constitutes a charge, which is placed in a narrow brass tube about 10 feet long and is fired from it by means of compressed air. The "messenger" ascends into the air, and one end of the line drops to the ground while the other goes to the roof. A heavier line can then be attached and made fast by the people on the top of the building. The inventor claims that he can fire his lines to a height of 200 feet. In order that the end of the line that drops to the ground could be readily found at night, he proposes to illuminate it with phosphorus.

An application for the Pneumatic Cotton Harvester Co., capitalized at $250,000, and backed by Memphis and St. Louis capitalists, has been filed with the register of Shelby County, Mo. The company will manufacture and sell a pneumatic tube cotton picker.

The mechanism of the machine consists of a four horse-power gasoline engine, rotary fan, and a number of rubber tubes. The engine will be geared to the fan, which will be revolved at great speed, creating a vacuum in the air chest with which it has connection. This vacuum will be communicated to the rubber tubes which are to be applied to the cotton bolls, sucking the cotton from them by pneumatic force. The apparatus is to be placed in an ordinary farm wagon.

The machine is operated by men who will fit the tubes to the bolls. It is claimed one man, with one of these tubes, can gather as much cotton as four or five pickers.

A pneumatic system of sewage disposal on the Liernur principle at Stansted, England, is described as follows in a recent issue of *The Surveyor:* Stansted is a scattered village in a hilly country, but the pneumatic system seems to have worked well since it came into operation a few months ago. The pumping station, containing a receiver, vacuum pump and gas engine, is in the lowest part of the village, the sewage being conveyed there by a network of 4-inch iron pipe about one mile long, with another mile of house connec-

tions. The receiver and pipes are kept in a constant state of partial vacuum, so that there is a steady flow, but the full vacuum (about one-fifth of an atmosphere) is applied for ten minutes every morning, which completely clears the house receptacles and sewer-pipes, leaving them clean and dry. There is no need for special flushing, disinfecting the manholes or ventilating shafts. The work of laying the sewers was carried out by Mr. E. T. Watts, surveyor to Stansted Rural District Council.

The Haeseler-Ingersoll Pneumatic Tool Company, No. 26 Cortlandt street, New York, have issued a pamphlet describing their axial valve hammers. In this the valve is a radical departure from the various forms of straight line reciprocating valves ordinarily used. As its name implies its movement is around a fixed axis, the travel forward and back, to alternately open and close the admission and exhaust ports, being caused by a constant air pressure upon the short wing of the valve and intermittent air pressure upon the long wing. The ports in the valve, as well as those in the valve box, are relatively of equal areas, and are located diametrically opposite to each other, so that any pressure against either side of the valve is equalized by a corresponding pressure upon the other side, resulting in a perfectly balanced valve and a consequent absence of friction.

Much of the delay in the adoption of compressed air for cleaning machinery has probably been caused by the cumbersome and complicated compressing appliances that were employed for a long time; but this objection no longer exists, as simple, durable and compact air compressors suitable for this purpose are now obtainable. The electrically-driven compressor is by far the simplest and most desirable for railway shops, and it is always available by simply closing a knife switch. The operator does not need to know anything whatever about the compressor, and as skilled attendance is not required, pneumatic appliances may be intrusted to ordinary laborers about the car shops and power houses, and the same class of help can be utilized for using many pneumatic tools. There are many little things about a shop that can be done when compressed air is available, and which effect small economies in themselves, but aggregate a considerable sum in the course of a year.

It would be an instructive inquiry for a committee of English engineers, who might be appointed, why the bulk of the air-compressors on the Rand are either American or German, and only the few of British make. Certainly one of the answers would not be that the trade is not worth having. Apparently, also, in the matter of quality, English manufacturers have little to learn, their machines being universally conceded to be superior to those made in other countries. This statement, however, seems to require some qualification, for one observer states that the only British air-compressor which he saw on the Rand was said to cost 30 per cent. of its total value in yearly repairs. Price, possibly, accounts for the preference being accorded the foreigner; an any case, the engineers' committee suggested would be able to discover the cause, and it might even pay the makers of these machines to engage the salaried services of such a committee, who could complete their labors by an inquiry on the spot. According to trustworthy accounts, only a little energy is needed to secure a much larger share of the trade than now falls to British firms. A hint that has been thrown out for the improvement of these appliances is worth repeating here, viz., that the compressor cylinders should be made of greater capacity than the normal size to allow for the rarefied atmosphere on the Rand and Rhodesian mining fields.

Italy has discovered an original method of combining business and matrimony. On the occasion of the great exhibition which is to be held at Milan to celebrate the opening of the Simplon Tunnel the committee is organizing a beauty show among girls from eighteen to twenty-six. The number of these graces must not exceed eighty-three. In connection with this competition a lottery has been established, the money from the sale of the tickets being awarded to the prize beauties as a marriage portion. Thus he who wins the first prize ticket in the lottery gains the prize Venus and 1,000,000 lire, four second prizes will assure the four next beautiful girls and 500,000 lire, eight thirds secure pretty partners for the gainers and 250,000 lire, twenty fourth prizes take a good-looking girl and 100,000

lire, while the remaining fifty competitors in the beauty show go to those who win with 50,000 lire. A million lottery tickets at ten lire each will, it is expected, be sold, while the entry money of the rival beauties will help to raise the 10,000,000 lire required for the prizes. According to the number of tickets sold to each buyer he will receive so many photographs of the eighty-three different beauties; thus he can make up his mind beforehand which he would rather win. Every ticket will be accompanied by a small pamphlet giving the biography of each girl. If the winner refuses to marry his prize or if she should refuse the winner the amount of the fortune will be divided between the two.

The braking of high-powered cars is one of the most important problems in automobiling. The presence at the recent Chicago show of what is probably the first motor vehicle to be equipped with air brakes is therefore interesting. The machine in question has a small air pump, driven by a cam on the crank shaft, which forces air into a tank. The pump is provided with automatic mechanism that can be adjusted to throw it into action when the pressure in the tank falls below a given point, say 60 pounds, and out of action when it reaches 80 pounds per inch. Connected with the air tank by a tube is a small cylinder on th: rear axle having two oppositely acting pistons that when pushed outwardly expand friction shoes in brake drums on the rear wheel hubs. Each stop of the car uses about two pounds of pressure, so that if the pressure is up to 80 pounds, ten stops can be made before it falls to 60 and the pump is put into action again.

The compressed air is also used for blowing a whistle and for forcing gasoline from a large tank under the rear of the body into a smaller tank on the dash, which is provided with a gauge glass so that the operator can always see how much gasoline is in the small tank, which feeds the carbureter. By connecting a hose direct to the air pump the tires can be inflated to 150 pounds pressure.

On the dash is a double gauge that shows the air pressure in the tank and the pressure in the water circulatory system, whereby, if there is any stoppage of the circulation, the driver will be promptly made aware of it.

A number of mining engineers recently visited the works of Messrs. E. Scott & Mountain, Ltd., at Newcastle-on-Tyne, England, in order to inspect a combined "Reavell" air compressor and "Scott & Mountain" continuous-current electric motor, which has been designed for use in collieries, where it is not possible to take electricity to the face. In collieries, where much gas accumulates in the face, and where it is advisable to have coal-cutting, rock-drilling and other machinery, it is safer, and, in some cases, more satisfactory to use compressed air than electricity, and the above-mentioned compressor is specially designed for such positions. The motor and compressor may be placed in the in-take, or as close to the position where the power is required as possible. The compressor is of the single-ended type (they are also made double-ended, *i. e.,* with the motor between the two compressors), the power being transmitted direct to the compressor shaft, which runs at a speed of 275 revolutions per minute. The compressor is of the double-stage pattern, and will deliver 150 cubic feet of air per minute at a pressure of from 80 to 100 pounds per square inch. The motor is an 88 horse-power Scott & Mountain continuous-current machine, but three-phase motors can be used if desired. The same type of compressor is also suitable for driving drifts in collieries where compressed-air drills are used. The compressor which was on view was to the order of Messrs. Walter Scott & Middleton, Ltd., and is to be used in connection with the excavations for the Great Northern and Strand Railway.

An important invention in connection with trolley arms used on electric cars to take the current from overhead wires is credited to C. V. Greenameyer, mechanical engineer of the Pacific Electric Company. Under the high speed that is sometimes attained, especially in the suburbs of cities, it has been noticed that the trolley wheel is in contact with the wire only part of the time. Much power is in this way undoubtedly lost, through the formation of arcs in the circuit, thereby transforming into light and heat the energy that should be used for propulsion of the cars. In his investigations as to the cause of this trouble, Mr. Greenameyer concluded that it is due to the spring used at the base of the trolley arm, and he has originated a

device by which the spring is supplanted by compressed air, which not only keeps the trolley wheel closer to the wire, but also prevents any damage to the overhead construction in case there is a jump of the wheel from the wire.

The trolley arm swings on a swivel on top of the car, with the rope dangling from its end, as is now the construction. Through pressure exerted by an air cylinder attached to the trolley arm the wheel is pressed against the wire. Should the wheel be forced from the wire on a trip the air pressure is released automatically and the arm falls to a point out of range of cross wires, instead of flying upward, as is now the case, to the destruction of the supporting wires sometimes, and also of the arm itself. The new trolley arm may be replaced in position by the turning of a lever at the hand of the motorman, the conductor at the same time using the guide rope, as at present used. One peculiarity pointed out is that the greater the speed the more surely does the wheel remain on the power wire.

Two "champing jaws" do the trick for the W. J. Clark's Quick As Wink Hose Coupling. A single push forces them over the shouldered groove of the companion piece—the other half of the coupling—and in an instant you have a joint that is absolutely air-tight. A spring holds the jaws together, but when the pressure is on no amount of rough handling could make them release their grip, even if the spring were not there.

The Quick As Wink Coupling will not come apart until you want it to—till you separate the jaws, with the thumb-levers or with the small flat key (whichever style you prefer). In either case connection is broken *in an instant.*

The Engineering Agency, 1208-9-10-11 Monadnock Block, Chicago, was started in 1893 by Mr. F. A. Peckham, at that time Western Manager of the *Engineering News.* Mr. Peckham found in traveling about the country that he was constantly asked by manufacturers where they could find certain competent help. On the other hand, his office was visited every day by those who thought his paper might be able to assist them to positions.

The agency has grown steadily, and during the past ten years has secured positions for over 5,000 technical men. The registrations during the past two years have exceeded 3,000, and yet to-day the agency has difficulty in securing enough competent men to supply all of the demands made upon it by companies that wish high-grade help. It is therefore using the "want" columns of some fifty leading papers throughout the country. Every person who registers in the "Engineering Agency" is

obliged to give a complete record of his past experience, and if the agency thinks that the experience is not satisfactory it refuses to permit the applicant to register; if it does accept the registration fee, but finds upon investigating the references that he is not such a man as the agency wishes to recommend, it returns to him promptly the registration fee. The care taken to register only competent men and to recommend always the right man for the right place, together with an experience of ten years with the leading railways, manufacturing and industrial companies, enables the agency to secure positions promptly for almost any high-grade technical man who can furnish a good record and references.

Mr. F. A. Peckham, President of the agency, was for twelve years with the *Engineering News;* Mr. A. B. Gilbert, Treasurer, has recently completed over eleven years' work for the same paper, during six of which he was Assistant Manager; Mr. A. G. Frost, Secretary, has been connected with the agency for several years.

The summer plans for the F. F. Proctor circuit of theatres, New York city, have been practically completed, and steady employment is promised to the large number of actors in Mr. Proctor's employ, and, best of all, a gay season of highly entertaining shows for the public at large. Later on there will be a revival of several of last season's biggest hits, and then there will be produced in quick succession half a dozen gay pieces never before seen in New York. All those productions will be as carefully made as though the season were at its height, for it is never Mr. Proctor's idea to curtail expenses, be the season early or late. At his Twenty-third street theatre the plan of presenting all vaudeville shows will be continued throughout the summer, the bills being made up with special reference to the warm weather. At his One Hundred and Twenty-fifth street house, Fifth avenue and Fifty-eighth street theatres the favorite stock companies will continue their excellent work.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

THE NORTH STAR MINES,
GRASS VALLEY, CAL.

Editor of COMPRESSED AIR,
New York City:

DEAR SIR—In your February number Mr. Place seems to think that there can be no appreciable drop in temperature of compressed air escaping through an orifice into the atmosphere (only about one degree F. for each atmosphere). By using an engine to pass his air through he claims getting a loss in heat precisely equivalent to the work by the engine.

If he will take his engine cylinder and fill it with air compressed to, say, ninety pounds, shutting off the supply, open the pet cock and hold his thermometer in the escaping air he will get a temperature of thirty or more below in the few seconds it takes to empty the cylinder. In other words, if he will keep his piston in his cylinder still and let the compressed air in and out of it, taking care to cut off the supply during the exhaust, he will get the same low temperature, or loss of heat, and the air will have done no work, as I understand it.

Very truly yours,

ARTHUR DEWITT FOOTE.

[That work of some kind is done when air is expanded and that the equivalent is the cold evidenced, we think is a general axiom which should be accepted. It is not necessary, of course, to do this work in pushing the piston of an engine, as it might be done in the shape of internal work; that is molecular work.

We should be very glad to have you send us any report you may care to make of your experiments for measuring compressed air under pressure and by means of the flow from orifices.

The subject of metering or measuring volumes of compressed air is a very important one, and, so far as we know, there is no device at the present time which can be relied upon for this purpose.—ED.]

Editor Compressed Air:

Sir—We have noticed quite a number of articles in your book about the use of oil for lubricating air compressors and would esteem it a great favor if you would give us some information as to what is the best oil for this purpose. We have two stage compressors, and our terminal pressure is from 100 to 120 pounds. So far we have been using what is called * * *, and we have been told that it was rather a bad oil to use for that purpose and that we ought to use "Renown" engine oil, and feed it into the air cylinders the same as we have been doing with the * * * oil. Kindly advise us your opinion of either of the above-mentioned oils and whether there is another make of oil that you can recommend. The party who recommends "Renown" oil claims that the Ingersoll-Sergeant people, after a good deal of experimenting, found the "Renown" to be the best all-around oil for use in air compressor cylinders.

Thanking you in advance for any information you may give us, we remain,

Very truly yours,

Heine Safety Boiler Co.

[We acknowledge receipt of your letter of April 1 relative to the use of oils for lubricating air compressors. This is a subject which has aroused a great deal of interest lately, and we are glad to see that it is receiving the attention which its importance warrants.

Owing to the frequent inquiries which we have received from various sources, we recently published a brief article on the general subject of lubrication, and we have from time to time published reports of accidents resulting from the use of inferior grades of oil, rich in volatile matters.

We also refer you to Compressed Air for November, 1902, where you will find an article containing some very valuable information on the subject.

Relative to the * * * oil, we frankly say that we do not know anything about it other than it is an oil largely used for machine lubrication. The "Renown" engine oil we know to be a good oil for air cylinders, and a great many compressor operators are partial to it, and we think that you should have no trouble if you use "Renown" oil. We also refer you to our advertisers, some of whom handle high-grade oils.

We would, however, advise against the use of too much oil, no matter what the make. The air cylinder lubricators should be adjusted to feed regularly a smaller quantity than is necessary in the case of a steam cylinder. They should also be watched carefully to see that they do not get to feeding faster than necessary or that they do not clog up.—Ed.]

Hamilton, Ont., April 24, 1903.

Editor Compressed Air:

Dear Sir—I received your book, *Compressed Air Information,* and prize it highly.

I notice an article on "Hydraulic Plant for Compressing Air," by H. D. Pearsall, of London, Eng., on page 173, and read the same with some interest.

I would like if you could give me any further information on the particular appliance he writes of. Have you any drawings showing how the water is controlled by the valve, or can you inform me where I can see any drawings of it on this side of the Atlantic?

Your favor will much oblige,

Yours truly,

Walter Anderson.

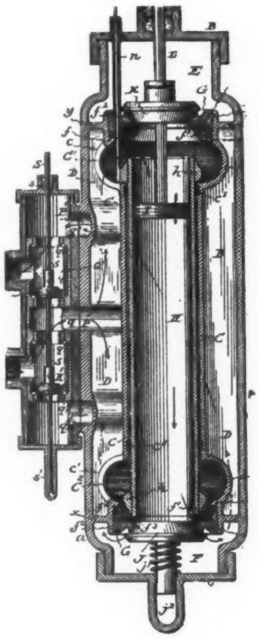
INDEX.

U. S. PATENTS GRANTED MAR. 1903.

Specially prepared for COMPRESSED AIR.

721,662. AIR-PUMPING APPARATUS. Byron B. Bower, Bainbridge, Ga. Filed Aug. 21, 1900. Serial No. 27,607.

The combination with a frame or casing having a chamber at each end formed by internal flanges, a cylinder-guide extending between such flanges and formed with an enlarged chamber adjacent each such flange and provided at its open ends with internal and external valve-seats, of an endwise-movable cylinder entirely open at its ends which extend



into said enlarged chambers and is formed with a valve at each end adapted to seat against said internal valve-seats, automatically-acting valves seating against said external valve-seats, a piston reciprocating in said cylinder, its piston-rod passing through one of said automatically-acting valves and ports and passages for admission and expulsion of air.

721,743. PNEUMATIC COTTON-CONVEYOR. George E. Richmond, Houston, Tex. Filed Nov. 21, 1902. Serial No. 132,263.

721,752. COMPRESSED-AIR SPRAY. Lloyd Scruggs, Omaha, Nebr. Filed July 22, 1901. Serial No. 69,170.

721,877. RAILWAY-MOTOR-VENTILATING SYSTEM. John H. Fedeler, Schenectady, N. Y. Filed Dec. 6, 1902. Serial No. 134,175.

The combination of a railway-car, an electric motor thereon, a source of compressed air, pipes leading from said source to the motor and pipes from the motor to the interior of said car.

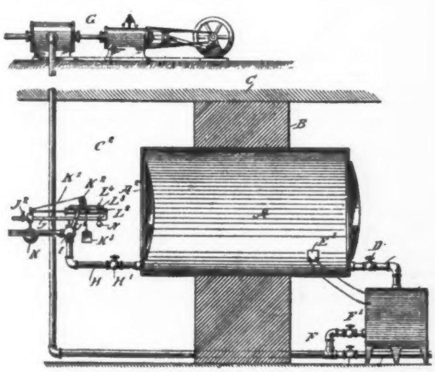
The combination with a railway-car and an electric motor thereon, of means for passing air over said motor, and a passage for the air thus heated from the motor to the interior of the car.

721,960. MEANS FOR REMOVING SLEET, SNOW AND ICE FROM THIRD RAILS. Peter Lindemann, Westchester, N. Y. Filed Jan. 7, 1903. Serial No. 138,118.

A third-rail electric railway, a sand-blast nozzle connected with a car or motor adjacent to the contact-shoe and adapted to discharge a blast onto the contact-surface of the rail, substantially as shown and described.

A third-rail electric railway, a sand-blast nozzle connected with a car or motor adjacent to the contact-shoe and adapted to discharge a blast onto the contact-surface of the rail, said sand-blast nozzle being under the control of the motorman, substantially as shown and described.

721,991. SAFETY AIR-LOCK. Walton I. Aims, New York, N. Y. Filed Dec. 17, 1902. Serial No. 135,494.

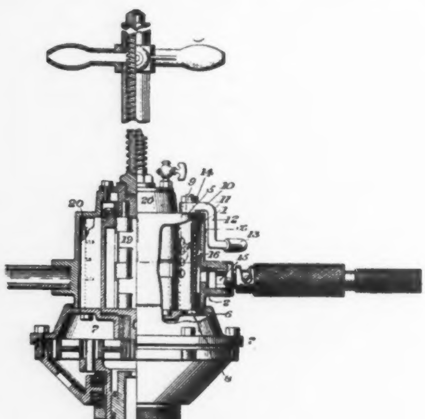


An air-lock having means for regulating the exhaustion of air from the lock, and means for simultaneously supplying heated air to the lock, as set forth.

An air-lock having an air-escape, a time-controlled device for the said air-escape, to cause a gradual reduction of pressure in the air-lock, an air-supply for the said air-lock, and heating means for heating the air previous to its entrance into the lock, as set forth.

722,179. REVERSING-VALVE FOR COMPRESSED-AIR MOTORS. Julius Keller, Philadelphia, Pa., assignor to Philadelphia Pneumatic Tool Company, a Corporation of New Jersey. Original application filed Aug. 13, 1902, Serial No. 119,479. Divided and this application filed Sept. 4, 1902. Serial No. 122,021.

A reversing-valve, consisting of a cylinder, a passage therethrough, open at its bottom and closed at its top, a longitudinally-extending



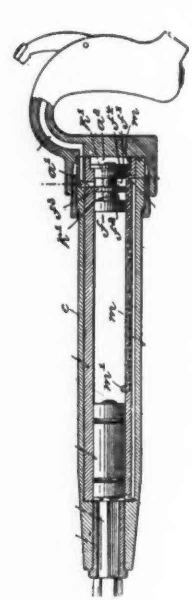
external groove on one side of said valve, and ports on the opposite side of said valve, whereby the latter is adapted to permit the entrance and exhaust of the motive fluid, the latter initially passing around said groove, in combination with an engine-cylinder in which said valve is mounted, handles therefor, one of said handles serving as an inlet-pipe, said valve being located in said cylinder between the rotary engine and said handle.

722,369. PNEUMATIC STACKER. Charles N. Leonard, Indianapolis, Ind., assignor to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed Apr. 14, 1902. Serial No. 102,722.

722,403. AIR-BRAKE. Joseph Farrar, Montreal, Canada. Filed Mar. 18, 1902. Serial No. 98,837.

722,614. PNEUMATIC HAMMER. Samuel Oldham and John J. Padbury, Philadelphia, Pa., assignors to George Oldham and Samuel Oldham, trading as George Oldham & Son, Frankford, Philadelphia, Pa. Filed Apr. 12, 1901. Serial No. 55,462.

In a pneumatic tool or hammer, a cylinder, a piston or hammer adapted to reciprocate in a portion of said cylinder, a valve adapted to reciprocate in the remaining portion of said cylinder and means controlled by the move-



ment of both piston and valve for admitting live air or fluid to the cylinder above the piston on its down stroke in varying volume, so that the downward movement of the piston is accelerated after it has begun to travel.

723,230. PNEUMATIC BRANDING AND HEATING IRON. John H. Belz, St. Louis, Mo., assignor of one-half to Ben Steyermark, St. Louis, Mo. Filed May 26, 1902. Serial No. 108,944.

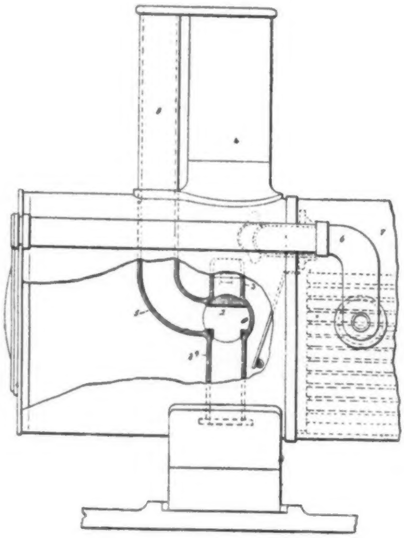
723,297. DUPLEX AIR-BRAKE SYSTEM. William H. Nightingale, Philadelphia, Pa., assignor to John E. Reyburn, Philadelphia, Pa. Filed May 20, 1902. Serial No. 108,157.

723,457. PNEUMATIC-DESPATCH RECEPTACLE. Emanuel C. Gipe, Chicago, Ill. Filed Jan. 6, 1902. Renewed Jan. 22, 1903. Serial No. 140,178.

723,870. PNEUMATIC STACKER. John Henry, Grand Forks, N. D. Filed Nov. 2, 1901. Serial No. 80,924.

724,183. COMBINED STEAM AND COMPRESSED-AIR LOCOMOTIVE. Ebenezer Hill, South Norwalk, Conn. Filed Apr. 1, 1902. Serial No. 100,908.

A combined steam and compressed-air locomotive, the combination with a boiler, of a



steam cylinder, means for distributing steam in the said cylinder, a compressed-air reservoir, means for supplying the said boiler and hence the said cylinder, with compressed air, and means for relieving the fire of the locomotive from the suction of its exhaust.

724,180. PNEUMATIC SWITCH APPARATUS AND VALVE THEREFOR. Lawrence Griffith, Yonkers, N. Y. Filed Apr. 18, 1902. Serial No. 103,523.

In a pneumatic apparatus, a slide-valve comprising a seat having inlet and outlet ports, an under slide adapted to slide on said seat and having ports adapted to be put into registry with the ports of said seat, a top slide adapted to slide on said under slide and having ports adapted to be put into registry with the ports of said under slide and therethrough with the ports of said seat, and means for moving the top slide in two directions whereby it must make a complete stroke in either of said directions before commencing the stroke in the other direction, and for carrying with it said under slide for a part only of such complete stroke.

724,302. ENGINEER'S AIR-BRAKE-CONTROLLING VALVE. Joseph Lipkowski, Paris, France, assignor to Societe Generale des Freins Lipkowski, Paris, France. Filed Jan. 31, 1903. Serial No. 141,317.

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No. 1 Extra Drill, Capacity 1¼ in. weight 49 lbs.

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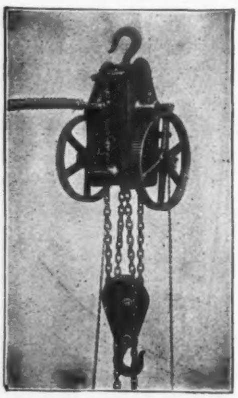

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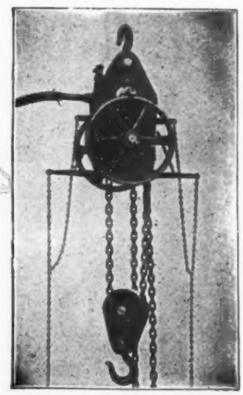

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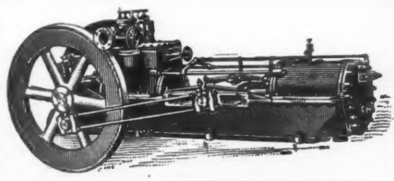


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